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MAMMOGRAPHY

The Roentgenographic Diagnosis of Breast Tumors by Means of Contrast Media

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THE clinical differentiation of mammary neoplasms presents a baffling diagnostic problem. It is extremely difficult to separate the benign from the malignant lesions and yet effective therapy is predicted on this differentiation. In appreciation of this dilemma, several precisional tests have been developed, all of which aim to minimize our diagnostic errors. Cutler introduced transillumination as a method of segregating the solid from the cystic and the infiltrating from the encapsulated tumors. Lockwood and Seabold popularized the roentgenographic study of the soft mammary tissues as a means of classifying the offending neoplasms. Ewing suggested that histological studies of aspirated tumorous tissue might afford an accurate and safe method of diagnosis. Meritorious as these procedures may be, they all have undeniable limitations which preclude their general adoption.

Eighteen months ago, a patient entered the hospital complaining of a bloody discharge from the nipple. Careful examination of the right breast revealed a dilated lactiferous estuary from which bright red blood could be expressed. Palpation and transillumination and soft tissue roentgenograms all failed to locate the bleeding tumor. As we (2) had been visualizing the biliary tract by introducing radiopaque materials into the gall bladder and bile ducts at the time of operation, it seemed reasonable to believe that the ductal system of the breast might be visualized by the same procedure. Therefore, the bleeding estuary was cannulized by a blunt No. 25 gauge needle and 4 cubic centimeters of lipoiodine was introduced. The resultant roentgenograms gave an exact pattern of the injected lobule and revealed a large dilated duct which harbored the troublesome neoplasm. So definite were the findings and so exact was the anatomical reproduction of the lactiferous ducts that the diagnostic value of such a procedure was immediately appreciated. Accordingly, 56 patients who exhibited physiological or pathological changes of the mammary gland were studied by 314 contrast roentgenograms, many of which were checked by gross and microscopic examination of the excised tissues. The results were so interesting that they merit reporting.

TECHNIQUE

This procedure utilizes contrast fluids which are injected directly into the milk ducts, thus

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giving an accurate roentgenographic pattern of the ductal and secretory system of the mammary gland. The terms "mammography" and "mammograms" have been coined to describe these examinations.

The technique of mammography is very simple. The breast is thoroughly cleansed as for any surgical procedure. Gentle massage of the nipple expresses small droplets of secretion or inspissated plugs of material from the lactiferous ducts. In this manner, the openings of the ducts are accurately located and can be readily cannulized by a blunt No. 25 gauge needle (Fig. 1). The contrast fluid is then injected into the duct until a sense of discomfort is experienced by the patient. This is repeated until all available ducts, usually 8 or 10 in number, have been injected and then stereoscopic roentgenograms are taken. Gentleness, persistence, and patience are requisite in obtaining good mammograms.

The contrast media used were thorotrast (thorium-dioxide, Heyden), lipoiodine (Ciba), hippuran (Mallinckrodt), diodrast (Winthrop), bismuth oxychloride (Mallinckrodt), 15 per cent sodium iodide, and air. Of these, thorotrast proved to be the most suitable. In addition to being the least irritating, it possesses the distinct advantage of having a sufficient fluidity to permit it to enter the smallest lacteals and still be dense enough to cast a satisfactory shadow. Lipoiodine is non-irritating but it is so viscid that it does not readily flow into the small ducts and acini. This objectionable feature has been partially overcome by heating the solution to 120 degrees F. prior to injection. Diodrast and hippuran readily permeate the walls of the lactiferous ducts and extravasate into the periductal tissues, thus giving a hazy roentgenographic pattern. Bismuth oxychloride and 15 per cent sodium iodide have both been used in necropsy and excised specimens, but they are too irritating for clinical purposes. Air is not only an excellent contrast medium but it is non-irritating and is quickly absorbed by the tissues. Unfortunately, however, the milk ducts are so small that they will not hold a sufficient amount of air to cast a satisfactory shadow. Hence, its use is limited to those patients having large cystic cavities of the breast.

Tumors originating in the periductal tissues or sequestrated cysts which do not have a patent communication with the estuaries of the nipple cannot be visualized by injecting the milk ducts. In such instances, an exploring needle is plunged directly into the tumor mass and if cystic, its contents are aspirated and replaced by air or other contrast media. When air is used, the "aeromammograms" clearly depict the limiting walls of the cysts, denoting whether they are single, multilocular, or papillomatous. Dense contrast media give an excellent stereoscopic view of the breast and definitely locate the offending tumors.

The most satisfactory mammograms are those made with the patient in the lateral recumbent position as demonstrated in Figure 2. This position not only permits visualization of the breast but also shows whether the axillary lymph glands are enlarged.

After developing the technique of mammography and after having tested its diagnostic value over a period of 16 months, I made a careful review of the literature. It was then found that in 1929, Ries had vaguely referred to this subject when he reported a case which had been referred to him with "an abscess of the breast following the injection of diagnostic lipiodol into the milk ducts." He did not give the name of the physician who had previously injected the breast nor did he repeat the procedure. In his very brief report he states that the milk duct which harbored the papillomatous tumor was visualized. He was not interested, however, in the diagnostic possibilities of the procedure but closed his discussion by saying: "While the demonstration of the size and shape of the milk ducts by lipiodol was perfect, the sequelæ may suggest considerable caution in the application of this procedure." He found it necessary to perform a segmental resection of the abscessed breast. In spite of a careful review of the medical literature, no other reference to this type of work could be found. Some articles, however, may have been overlooked.

An experience with 56 patients and postmortem subjects indicates that these mammographic visualizations afford an excellent

Fig. 1, left. Cannulization of milk ducts with a blunt No. 25 gauge needle. Aseptic technique used.

Fig. 2. A lateral position is preferred for roentgenograms. Meyer's angle board facilitates stereoscopic studies.

method of studying both the physiological and pathological changes of the breast. Clinically they have a very definite diagnostic value for by them one can differentiate localized from infiltrating growths, solid from cystic tumors, and simple retention cysts from cystic degeneration of the breast. Also, one can locate and determine the size and number of papillomas present. Progress studies on the same patient testify to the uniformity of findings. These assumptions can best be proved by actual case presentations.

Normal breast. As these visualizations were entirely new, there were no established normal patterns to be used as guides in interpreting pathological findings. Studies were made, therefore, of the normal breast in all of its functional phases and in various age groups, so the physiological variations could be properly appreciated. In many instances, roentgenographic findings were confirmed by gross and histological examination of the injected mammary lobules. Figures 3, 4, and 5 are actual photographic reproductions of the ductal and secreting system of the mammary gland as seen in some of its functional states.

Papillomas. Papillomas of the breast can readily be detected and localized by these mammographic studies. Clinically, these tumors announce themselves by producing a bloody discharge from the nipple. This escaping serosanguineous fluid accurately locates the stomas of the diseased milk ducts and facilitates their cannulization. Being a proliferative type of tumor which protrudes into the lumen of the duct or the dilated cystic cavities, a papilloma presents characteristic filling defects of the involved structures. Hence, it can readily be recognized by the contrast injections.

CASE 1. Mrs. L. McC., housewife, 28 years of age, sought medical advice because of a bloody discharge from the breast. Three months ago she noticed a small drop of blood on the right nipple but as this was not attended by pain she immediately dismissed any idea of danger. Two weeks later, while adjusting a brassiere, she expressed a

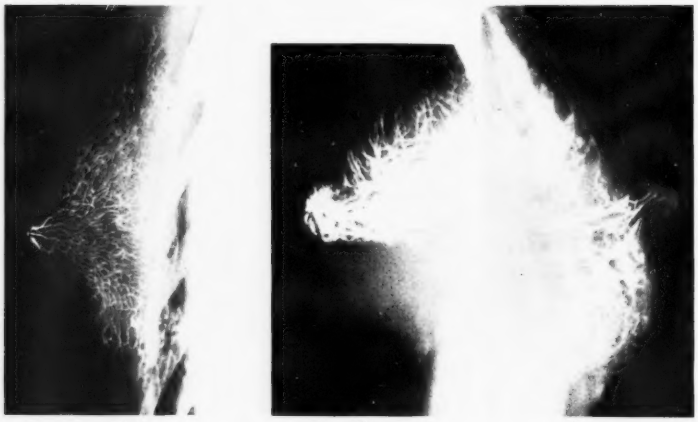

Fig. 3. Fig. 4. Fig. 5.

Fig. 3. A virginal breast. A mammogram of an 18 year old girl during the resting phase of her menstrual cycle. The lactiferous ducts are very small, the ampullæ are not dilated, and the acini are not visible. Compare with Figures 4 and 5.

Fig. 4. Early phase of lactation. One milk duct was injected with 4½ cubic centimeters of thorotrast on the third postpartum day. The milk flow was not established. Note the marked increase in the number of ducts and acini which form a dense network of tubules. This represents one breast lobule drained by a single duct.

Fig. 5. Multiparous breast in the non-lactating phase. This mother has nursed 3 children, the youngest being 3 years of age. The ducts are small, the ampullæ are again contracted but there is an increase in the amount of acinar tissue. Compare with Figure 2.

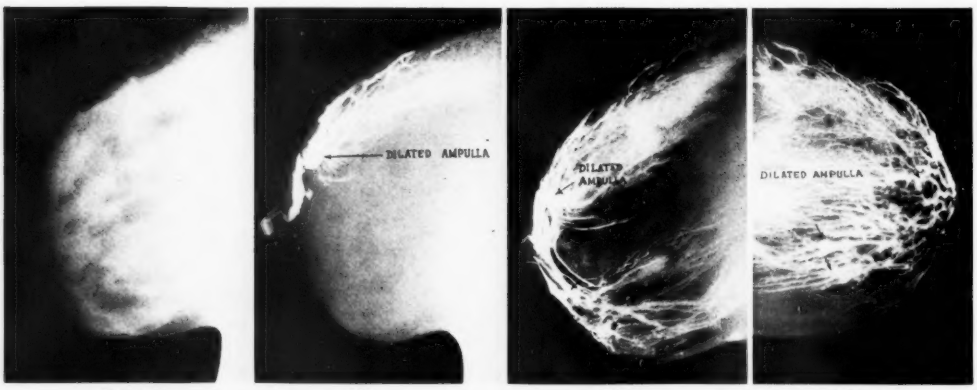

Fig. 6. Fig. 7. Fig. 8. Fig. 9.

Fig. 6. Case 1. Soft tissue roentgenograms show a definite increase in the amount of ductal tissue with some periductal fibrosis and a fatty infiltration of the breast. No tumor mass can be seen.

Fig. 7. Case 1. The bleeding duct was visualized by injecting it with 4 cubic centimeters lipoiodine. The arrow marks the widely dilated ampulla which harbored the small papilloma. Lipoiodine is much too dense to outline the contour of the tumor.

Fig. 8. Case 1. Six other ducts were injected with lipoiodine. Many of the ducts are dilated and enlarged, indicating that dilatation is not a disease of one lobule but of the entire breast. No attempt was made to visualize all of the breast.

Fig. 9. Case 1. Ten ducts of her normal breast were injected with lipoiodine. There is likewise a dilatation of these ducts emphasizing that the tendency toward cystic dilatation is bilateral. No papillomas are visible.

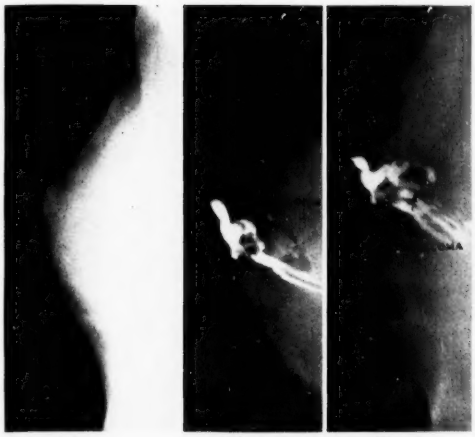

Fig. 10. Fig. 11. Fig. 12.

Fig. 10. Case 2. Soft tissue roentgenograms of the breast fail to reveal any pathological changes.

Fig. 11. Case 2. The bleeding estuary was injected with 1 cubic centimeter of thorotrast. There are two definite filling defects of the ductal lumen which are interpreted as being pedunculated papillomas. The terminal ducts are visible.

Fig. 12. Case 2. Three cubic centimeters of thorotrast injected into the same duct to rule out the presence of an artefact, such as an air bubble. Note that the same filling defect still persists.

Fig. 13. Case 2. A photograph showing the ducts which contain the two papillomas, thus confirming the mammographic findings.

half dram of bright red blood from the same nipple. This caused her some alarm but as the bleeding stopped within 2 hours she again dismissed the incident. About once a week since then there has been a sudden gush of blood from this nipple. She did consult her family physician but he was unable to locate the offending tumor. She gave no history of trauma, lactation mastitis, or cracked nipples. She nursed four children, the youngest being 2 years of age.

Examination revealed large pendulous breasts. No tumors, ulceration, or discharge from either nipple were seen. Palpation failed to demonstrate the presence of a tumor but the milk ducts were definitely enlarged, soft, and compressible. Pressure upon the upper outer quadrant of the right breast expressed 1 dram of bright red blood from the nipple. All the blood escaped from one estuary, its stoma being dilated and gaping. The entire breast was translucent and even soft tissue roentgenograms failed to locate the offending neoplasm. In the hope of visualizing the diseased lobule, the bleeding duct was cannulized and injected with 4 cubic centimeters of lipoiodine (Fig. 6) The resulting mammogram graphically outlined the pathological area and showed the duct to be enormously dilated. The ampulla was about five times its normal size (Fig. 7). Six other ducts were likewise injected and their dilated ampullæ were seen (Fig. 8). In order that the proper evaluation of these findings could be made, the normal breast was injected with the same contrast medium (Fig. 9). Its ducts were dilated and pouched with some small incipient cysts.

It was surprising to note the pronounced dilatation of all the lactiferous ducts in both glands. This was particularly noticeable when compared to the normal findings as represented in Figures 3 and 5. The fact that both breasts were involved lends credulence to the belief that many mammary diseases have a constitutional or endocrine basis, and it is also easy to understand why papillomas may be multiple.

Not desiring to have the deformity resulting from a unilateral mastectomy, the patient insisted that both breasts be removed. Macroscopic and histological studies confirmed the mammographic findings of dilated ducts. The lumen of the bleeding estuary measured 1.5 centimeters in diameter and harbored a very small pedunculated papilloma.

Case 2. Mrs. R. S., stenographer, 40 years of age, was seen in consultation with Dr. Charles Moon, because of a bloody discharge from the nipple. Three years ago she noticed a hemorrhagic fluid escaping from the right nipple but as this subsided spontaneously she gave it no thought. Since then a similar serosanguineous discharge has been observed on several occasions but it has only been during the past 2 weeks that bleeding has become persistent. There has been no pain or tenderness, and she has not observed any variation in the size of the breast during the various phases of the menstrual cycle. Likewise she has never been able to palpate a tumor in spite of frequent self examination.

The right breast was soft, spongy, and presented nulliparous characteristics. In the outer lower quadrant there was a soft compressible cystic tumor which seemed to be confluent with the dilated ducts.

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 14. Case 3. Soft tissue x-ray pictures outline a single, definitely delimited tumor of the breast.

Fig. 15. Case 3. One and one-half cubic centimeters of thorotrast injected into the duct which presumably drained the tumorous area. The duct is not dilated, it has but few branches and it does not enter the tumor but is displaced laterally by the neoplastic mass. Such a tumor cannot be visualized by injecting the ducts.

Fig. 16. Case 3. A needle was inserted into the tumor and 30 cubic centimeters of fluid was aspirated and replaced by 30 cubic centimeters of air. The aeromammogram reveals a large bilocular cyst with a partial septum indicating the fusion of two daughter cysts. The tumor does not communicate with the ducts.

Fig. 17. Case 3. The air was replaced by 30 cubic centimeters of thorotrast. Stereoscopic studies show this to be a sequestrated cyst which has lost its ductal continuity. Observe how the cyst displaces the injected ducts.

Compression of the cyst caused the ducts leading from this lobule to become distended and visible, but no secretion could be expressed. While palpating the upper medial quadrant three drops of bright red blood spurted from the nipple. All the discharge escaped from one dilated estuary. Meticulous palpation and transillumination failed to reveal any papillomatous tumors or cysts. The small cystic mass formerly described was very translucent. No apparent abnormalities were found in either breast by soft tissue x-ray studies (Fig. 10).

In order to determine the nature and location of the bleeding tumor the offending estuary was cannulized and injected with 1 cubic centimeter of thorotrast. The mammogram demonstrated a definite filling defect of the dilated milk duct. Apparently a proliferating, pedunculated tumor projected into and filled the ductal lumen. To preclude the possibility of this filling defect being an artefact, such as an air bubble, an additional 3 cubic centimeters of contrast medium was introduced into the same duct. The fluid was thus forced beyond the obstructing tumor mass and filled the terminal lacteals and acini. Not only did the filling defect persist but a second and similar tumor was observed at the bifurcation of one of the smaller communicating ducts (Fig. 11). Thus 2 papillomas were accurately visualized by these mammographic findings. In order to interpret these unusual mammograms correctly, an adjacent, non-bleeding estuary was cannulized and a contrast roentgenogram was taken. A comparison of the normal duct with the "papilloma-containing" duct clearly demonstrates the location and pedunculated nature of the offending neoplasms (Fig. 12). Appreciating that the patient had multiple papillomas, Dr. Moon performed the mastectomy.

A careful dissection of the excised breast clearly demonstrated a generalized dilatation of all the milk ducts. The bleeding ampulla had a diameter of 1.5 centimeters and it contained a pedunculated papilloma which completely filled its lumen. Two centimeters farther along the same duct was a second papillomatous tumor which plugged the orifice of one of the tributaries (Fig. 13).

It is thus evident that these mammographic studies not only have a definite diagnostic value but they aid in determining the position and number of existing tumors and thus facilitate correct treatment. No attempt was made to inject any of the other ducts for fear of damaging this specimen. A complete visualization of the breast could have been made, however, for 12 estuaries were identified.

Cystic tumors. Mammography finds its greatest usefulness in the study of cystic diseases of the breast. Not only can one determine the size, shape, number, and location of the troublesome cysts but one can also tell whether they are single or multilocular, whether they communicate with the ducts or

whether they are isolated or secluded. Likewise one can visualize neoplastic encroachment into the cystic cavities. Such information not only facilitates accurate diagnoses but it aids the surgeon in determining the extent of the diseased process, thus abetting correct treatment. The following cases verify these declarations.

CASE 3. Retention cysts. Mrs. M. McD., housewife, 51 years of age, accidentally discovered a small lump in the right breast about 18 months ago. It was hard, painless, and not tender. However, as the tumor increased in size she experienced a definite sense of fullness and "puffiness" in the breast. Since becoming "tumor-conscious" she has felt several small, pea size nodules in both mammary glands. Two weeks ago she fell and bruised her right shoulder. This produced severe pains in the right breast and has been the source of much alarm.

Both mammary glands were small, atrophic, and in close apposition to the chest wall. The left breast was 1½ times larger than the right and contained a visible tumor mass which pushed the nipple forward. The neoplasm was firm, movable, and not tender. Pressure did not alter its size nor cause any secretion to be expressed from the nipple. The ducts were all distended but were soft and compressible. In addition to the main tumor mass, multiple small nodules could be felt throughout the entire gland. All the tumors were definitely translucent, thus confirming the diagnosis of cystic disease of the breast. Soft tissue roentgenograms gave a hazy outline of the tumor masses (Fig. 14).

Hoping to visualize the cysts, one of the milk ducts which presumably lead to the large tumor was cannulized and 1.5 cubic centimeters of thorotrast was introduced. Roentgenograms showed that this duct did not communicate with the tumor but that it had been pushed to one side during the expansive growth of the neoplasm (Fig. 15). Four adjacent ducts were similarly injected but none of them communicated with the cyst. Apparently this was an isolated retention cyst which had lost its ductal continuity. In order to verify this conception, a No. 20 gauge needle was inserted directly into the tumor mass, 30 cubic centimeters of clear yellowish fluid was aspirated, and the cavity was distended with an equal volume of air. The air made an excellent contrast medium, for the aeromammogram revealed a centrally situated cyst. Note that the air was confined to the cystic cavity and did not communicate with the ducts and that there was a partial septum dividing the cavity into two sections, indicating that the parent cyst had been formed by the fusion of two daughter cysts (Fig. 16). The cyst wall was smooth and no evidence of an infiltrating or papillomatous tumor was seen. The air was aspirated and replaced by 30 cubic centimeters of thorotrast. It was interesting to note how the growing cyst had displaced the milk ducts laterally (Fig. 17). No attempt was made to inject the other small ducts and cysts.

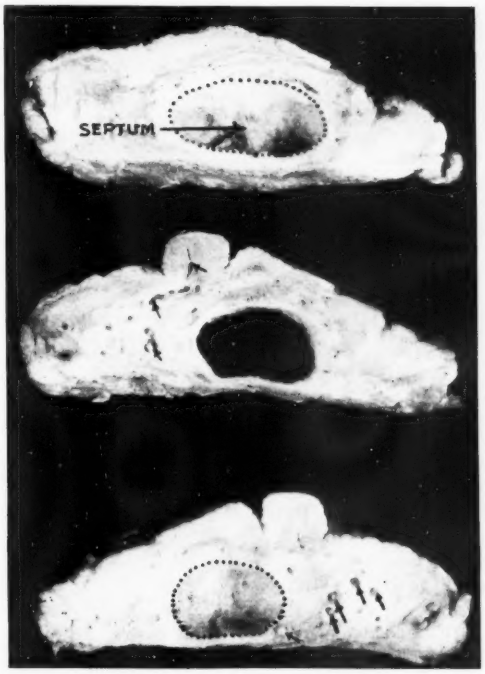

Fig. 18. Case 3. Transverse section of the breast demonstrates the large bilocular cyst with its partially dividing septum as outlined in the mammogram. Arrows point to the injected ducts.

A simple mastectomy was performed because of the generalized mastalgia and the multiplicity of the cysts. The photograph of the excised specimen confirms the mammographic findings (Fig. 18).

CASE 4. Galactocele. Mrs. A. M., housewife, 26 years of age, complained of an enlarging painful tumor in the left breast. Following the birth of her first child she had a mastitis for 6 weeks, after which all discomfort disappeared. Since that time she has had two miscarriages but no "breast trouble." During her last pregnancy, when but 1 month from term, she felt a tender painful tumor in the lower portion of the left mammary gland. It grew slowly until after her delivery and then during the past 10 days it has more than quadrupled its size. When the baby began nursing, the tumor became more prominent, tense, and distended. It was tender but not inflamed. Palpation revealed a discrete, tense, well encapsulated, walnut sized tumor in the median portion of the left breast. It did not feel cystic nor was it translucent. Soft tissue x-ray films failed to locate the tumor (Fig. 19). It was felt unwise to inject the ducts with thorotrast as the baby was

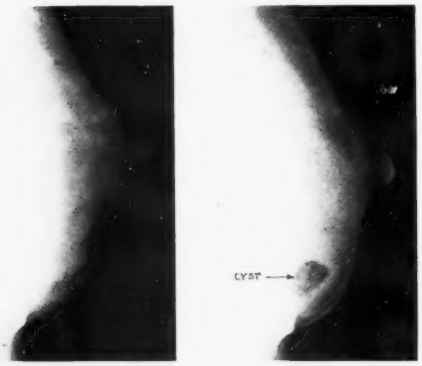

Fig. 19, left. Case 4. Soft tissue roentgenogram of the lactating breast fails to locate the offending tumor.

Fig. 20. Case 4. Seven and one-half cubic centimeters of milk was aspirated by directly puncturing the tumor and were replaced by 10 cubic centimeters of air. A smooth, thin walled retention cyst is seen. It does not have a patent communication with the ducts. Diagnosis: galactocele.

nursing the breast, so a needle was introduced directly into the tumor mass, 7½ cubic centimeters of viscid milk was aspirated, and the cavity was injected with 10 cubic centimeters of air. An x-ray picture was taken which demonstrated that the outlined cyst did not have a patent communication with the milk ducts but was a sequestrated galactocele (Fig. 20).

CASE 5. Cysts communicating with the ducts. Mrs. A. M. entered the hospital because of painful breasts. She had suffered from a mastalgia since childhood, particularly preceding each menstrual flow. Ten years ago she accidentally discovered a small tender nodule in the left breast. This tumor was excised and diagnosed as a "chronic cyst." Two years ago she noticed that similar "lumps" were developing in each breast but she was assured that they were benign and hence gave them no heed. During the past 6 weeks there has been a thick, greenish discharge from several milk ducts and both breasts have been so tender that she could not wear a brassiere. The pain has become intolerable.

On examination the mammary glands were found to be small, atrophic but exquisitely tender. Small pea size tumors could be felt in both breasts but the tenderness precluded a satisfactory examination. Gentle massage of the nipples expressed a thick greenish secretion, cultures and smears of which contained clumps of gram positive cocci. Soft tissue roentgenograms and transillumination failed to reveal the presence of any tumors. Hot moist packs were applied to the breast every 2 hours and endocrine therapy instituted. Four weeks of such treatment failed to give the desired relief, and she demanded that the breasts be removed because of the pain they produced.

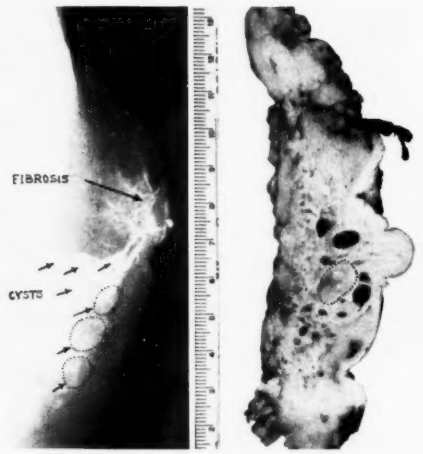

Fig. 21, left. Case 5. Eight cubic centimeters of thorotrast was introduced into 6 milk ducts. The lower portion of the breast has undergone cystic degeneration of the ducts. The upper segment is not clearly visualized as the fibrosis from the previous operation has occluded the ducts.

Fig. 22. Case 5. Examination of the gross specimen shows a multiple cystic degeneration of the breast. All the cystic cavities contained thorotrast. This confirms the mammographic findings.

Prior to operation thorotrast was introduced into 6 ducts. The mammogram revealed a marked cystic dilatation of the ducts. The upper quadrant of the breast could not be visualized for the fibrosis resulting from the previous operation had occluded the lumina of the ducts (Fig. 21). Unlike the former cases, these cysts were actual dilatations of the ducts and maintained a communication with the estuaries. Because of the extensive involvement of both breasts a bilateral mastectomy was done. Figure 22 confirms the mammographic findings.

Carcinoma. Carcinomatous tumors of the breast are not easily visualized by these contrast studies. The neoplastic cells not only invade and plug the ducts but they frequently destroy their normal continuity. Likewise if the infiltrating growth involves the subareolar ducts, then contrast fluid cannot be introduced into these obliterated lacteals. Nor is it prudent to massage malignant tissues; pressure may express neoplastic emboli into the lymphatic or vascular circulation. If the tumor is frankly carcinomatous there is no need for a diagnostic contrast injection. Occasionally, however, one meets a deep seated tumor of questionable nature which can be readily visualized and correctly diagnosed.

Fig. 23.

Fig. 24.

Fig. 25.

Fig. 26.

Fig. 23. Case 6. Soft tissue roentgenogram.

Fig. 24. Case 6. Two cubic centimeters of thorotrast was injected into a duct which traversed the tumorous area. The outer segment of the duct appears normal but the inner three-fourths presents a fine, trabeculated, spider-web appearance. In some areas the ducts are completely destroyed; in others they are being pushed apart by the proliferative tumor cells.

Fig. 25. Case 6. A neighboring duct was injected with 3 cubic centimeters of thorotrast. Note the same fine gossamer-like pattern of the ducts as if they were being destroyed by an invasive growth.

Fig. 26. Case 6. A mammogram of her normal breast. Note the dense network of patent, branching ducts of this breast as compared to the fine thread-like ducts of its malignant mate. Diagnosis of opposite breast was carcinoma.

Case 6. Mrs. H. K., housewife, aged 38, has been bothered with a "caked breast" since the birth of her last child 18 months ago. As soon as lactation began. the right breast became swollen, tender, and caked. Her physician informed her that this was a lactation mastitis and would soon subside. True to his prediction, the soreness did disappear but the upper outer quadrant remained hard and indurated. The child nursed both breasts for 10 months but the right did not produce as much milk as the left. During this lactation interval, the tumor seemed to grow and it became attached to the skin. Seven months ago the baby was weaned and since that time the tumor has almost doubled its original size. Two months ago, she felt a small lump in the right axilla. This has likewise grown and is now so large that it interferes with the free motion of the arm. During the past 3 months there has been a serosanguineous discharge from the nipple and the brassieres that she wears become soiled. The left breast has become much smaller since the baby stopped nursing.

Inspection demonstrated that the right breast was about five times larger than the left and that the upper outer quadrant harbored a large visible tumor. This mass was hard, not tender, and was attached to both the skin and underlying muscles. It measured 5 inches in diameter. There was a large agglomerate mass of lymph nodes situated beneath the pectoralis major and extending into the right axillary space. No supraclavicular nodes could be felt. Slight pressure on the tumor expressed a few drops of serosanguineous material from two gaping estuaries. The tumor mass cast a definite shadow on transillumination and no limiting capsule could be made out—rather the neoplasm seemed to blend into the normal translucent breast structures. Soft tissue films vaguely outlined extent of tumor (Fig. 23).

This was a frank carcinoma that developed in a gravid breast and then grew rapidly because of the stimulating influence of lactation. Desiring to know whether the bleeding originated in a carcinomatous invasion of the ducts or whether this might not be a papillomatous carcinoma, a mammogram was made. One of the bleeding ducts was easily catheterized, 2 cubic centimeters of thorotrast were introduced, and an x-ray film was made. The contrast medium had traversed the tumorous area. The outer segment of the injected duct appeared normal but the tumorous portion presented an unusual finding. It was small, thread-like and its ramifications resembled a fine cobweb (Fig. 24). The adjacent bleeding duct was likewise injected and presented similar findings (Fig. 25). Apparently the infiltrating neoplastic tissues had not only reduced the size of the ductal lumen by direct invasion, but the rapidly growing malignant cells exerted a definite obliterating extrinsic pressure. It was also interesting to note how some of the smaller ducts had been separated by the rapidly growing periductal tumor. In order that these findings might be properly evaluated the milk ducts of the normal breast were injected. They were large, patent, convoluted, and completely ramified the entire breast matrix (Fig. 26). This was a striking contrast to the gossamer-like pattern of the invading malignant tumors.

Experience with similar cases indicates that malignant tumors usually involve the ducts,

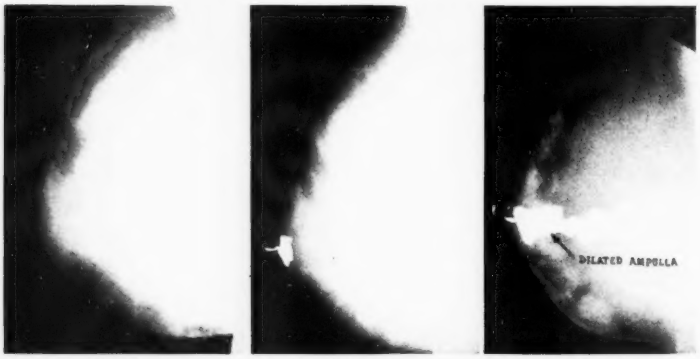

Fig. 27. Fig. 28. Fig. 29.

Fig. 27. Case 7. Soft tissue roentgenogram of an acute retention mastitis, merely evidence an increased density in the ductal and periductal tissues. Nothing characteristic observed.

Fig. 28. Case 7. Only ½ cubic centimeter of thorotrast could be introduced into the gaping duct as attempts to introduce more caused severe pain. The ducts are obstructed with retained secretions. This emphasizes the necessity of evacuating the ducts before attempting a mammogram. Compare with Figure 29.

Fig. 29. Case 7. The same duct, after evacuation with a breast pump, accommodated 7½ cubic centimeters of thorotrast. Note the enormous dilatation of the main duct and ampulla. Diagnosis: retention mastitis.

either by compressing, invading, or completely destroying them. In any event they produce an easily recognized ductal deformity which naturally permits a correct diagnosis. It should be emphasized again that if the tumor is frankly malignant, then no contrast injection of the milk ducts should be done.

CASE 7. Acute mastitis. Mrs. A. R., 26 years of age, had been nursing her baby for the past 8 months. Three days ago she decided to wean the baby and to let the breasts "dry up." Two days later both breasts were swollen, painful, and tender. The slightest pressure elicited severe paroxysms of pain. The breasts were found to be very distended, tender, and warm. The skin had a pinkish color and milk was oozing from many of the estuaries. Temperature was 100.8 degrees F.; leucocytosis, 15,600.

The diagnosis of an acute mastitis was made and conservative therapy, such as bed rest, saline purges, binders to the breasts, and limitation of fluids, was instituted. Four days later the breasts were much smaller and the pain had subsided. Soft tissue x-ray films evidenced a periductal fibrosis but did not reveal any localized abscesses (Fig. 27). Even though termed an acute mastitis, this was not an infective process for cultures of the expressed secretions were always sterile. It seemed more logical to believe that this was merely an acute passive congestion of the breasts caused by a complete retention of the mammary secretions. If this be true, then, the milk ducts should be enlarged and dilated. In order to confirm this assumption, one of the milk ducts was injected with ½ cubic centimeter of thorotrast. No more thorotrast could be introduced because of the resulting pain. The mammogram visualized but a small outer segment of the duct (Fig. 28). Apparently the retained secretions completely filled the ductal lumen and prohibited the contrast medium from outlining the entire breast lobule. To obviate this difficulty, the duct was evacuated by a breast pump and 7 cubic centimeters more of thorotrast was introduced into the same estuary (Fig. 29). Note the enormous dilatation of the ampulla and the distal three-fourths of the duct. Its tortuosity also signifies retention and engorgement. Hence, this visual pattern of the duct demonstrates that the so called acute mastitis was nothing more than a retention of the mammary secretions and the pronounced distention of the milk ducts produced the intense pain.

EVALUATION OF THE METHOD

Like all tests of precision, both contrast mammograms and aeromammograms have their limitations, but in spite of this it appears that they possess a definite diagnostic value. The correct diagnosis of mammary neoplasms has always been an enigma and perhaps these visualization studies will aid us in acquiring a better understanding and appreciation of the normal and pathologic breast. The seven clinical cases presented testify to the

value of these mammographic observations.

Injection of the estuaries is occasionally a tedious procedure and in some instances cannot be accomplished. If the nipple is inverted, if the ducts are occluded by fibrous or neoplastic cells, or if they have never been opened by escaping secretions, then some difficulty will be found in locating them. Likewise, no injection or manipulation should be done in the presence of an acute infection. In one instance, a fulminating breast abscess resulted from this unwise procedure.

Due to the fact that the milk ducts have a terminal protective sphincter which guards the ductal orifice, the injected thorotrast cannot escape from the ducts, and as it is absorbed slowly, it may remain in the breast lobule for as long as 5 months after injection. While it has not been irritating and has not produced any untoward effects, one cannot always hope for such results. However, the widespread use of this substance in cholangiography, ventriculography, arteriography, and hematogenous visualization of the spleen and liver would indicate that thorotrast has but a very mild tissue reaction and can be used with comparative safety. As soon as the mammographic studies have been completed a gentle milking massage of the nipple expresses the major portion of the injected medium, thus minimizing the amount to be retained. Application of the breast pump has likewise proved effective in decompressing the injected lobules.

In nearly every instance in which a lactating breast was injected the patient experienced some soreness and discomfort for a period of 12 to 24 hours. In 35 instances there was no interference with the milk flow and no mastitis or infection occurred. The transitory pains were of a mild nature and easily controlled by the application of hot moist packs. In the vast majority of patients, there was no post-injection mastalgia and no difficulty was encountered in getting them to submit to repetition progress studies. It is absolutely essential that strict surgical asepsis be practiced lest an infection be introduced. Experience breeds dexterity and familiarity with the breast which makes it a very simple matter to obtain good mammograms.

Diagnostically, the contrast mammograms are far superior to the soft tissue roentgenograms in the recognition of mammary tumors. In each of the 7 cases presented the mammographic studies gave an excellent visual pattern of the offending neoplasms while the soft tissue x-ray pictures were either indefinite or completely void of information. Apparently these mammograms will give us valuable information concerning the physiological and pathological changes of the breast, particularly in the diagnosis of breast tumors.

SUMMARY

1. Mammography is an efficient method of visualizing the breast by introducing contrast media into the small estuaries of the nipple or directly into the tumor mass. The contrast substances clearly outline the milk ducts and the offending tumors, thus facilitating accurate diagnosis.

2. Papillomas, simple retention cysts, cystic degeneration of the breast, galactoceles, carcinomas, and retention mastitis were diagnosed by these mammographic studies. The diagnostic value of these mammograms is shown by actual cases which were visualized by contrast roentgenograms.

3. The technique, the media used, the indications for and the complications occurring in these mammographic studies are discussed. The technique is described, particular emphasis being placed on the difficulties encountered, the advantages and disadvantages of various radiopaque materials used, and the contra-indications for visualization studies.

4. Three hundred fourteen mammograms have been made with but one resultant breast abscess, and in this instance the patient had a pyogenic mastitis prior to injection studies.

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THE DIFFUSE COLLOID GOITER

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AT the first International Goiter Conference in Berne, 1927, McCarrison, one of the greatest authorities on goiter, stated that there is little precise knowledge as to the geographic distribution and epidemiology of the diffuse colloid goiter, less as to its etiology and less still as to its biochemistry.

Not only has the study of this type of endemic goiter been entirely neglected by biochemists and experimental pathologists, but also in clinical treatises on thyroid diseases the diffuse colloid goiter occupies a surprisingly small space. Few clinicians seem to realize that, in North America, about 90 per cent of the surgical goiters develop in this structure.

The most common type of endemic goiter encountered in my autopsy and surgical material, is the colloid goiter. Aschoff distinguishes colloid goiter with hyperplasia and colloid goiter without hyperplasia. These are not separate entities. The transitional stages which one observes between them, suggest that both are different grades of the same functional stage. Also in the resting form of colloid goiter, there are buds of epithelial proliferation in the wall of some follicles. The cells become higher in these cushion-like elevations of the epithelial wall and new formation of small daughter acini is evident. In colloid goiter with hyperplasia, these proliferations are more extensive and much more frequent. The presence of this epithelial activity is the strongest argument against the conception that colloid goiter is the result of involution. In Marine's opinion, colloid goiter never does develop from a normal gland, but is preceded by hyperplasia. From my studies of human goiter, I believe to the contrary, that in level countries the thyroid reacts to the goiter agent with increased colloid secretion and that the colloid goiter develops from a normal gland.

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In regard to the function of the diffuse colloid goiter, most writers contend that it is hypo-active. According to Rienhoff, the basal metabolic rate of young girls with colloid goiter is usually subnormal and also Plummer and Boothby state that adolescent goiter lowers the basal metabolism from 8 to 18 per cent. From my examinations of nurses and college girls in Wichita, with and without enlarged thyroids, I do not have the impression that adolescent goiter in this country is associated with a low thyroid function. Most of the girls with colloid goiter had a normal or slightly elevated basal metabolic rate, and signs of hypothyroidism were entirely missing. My results corroborate the work of De Takats who examined college students with colloid goiter in Chicago.

Valuable as basal metabolic tests are in adults, they are fully as unreliable in young individuals. Such authorities as Benedict and Talbot admit that the present standard values for girls under 20 years of age are almost useless. There are differences sometimes as high as 20 to 50 per cent between the standard tables of Benedict and those of the Mayo clinic. In the goiter-free district of Charleston, S. C., Remington and Culp obtained basal metabolic rates of normal student nurses which were about 10 per cent below the Aub-Du Bois standards. The same observation has been made by Tilt on college students in Florida and by Conklin in Minnesota. Until we have more reliable normal values for the ages between 14 and 19 years, the function of the adolescent goiter cannot be determined by the laboratory, and we have to rely on clinical observation. I have never seen a case of myxedema with diffuse colloid goiter and, as far as I know, there has never been one reported. From my experience in level countries, I believe that diffuse colloid goiter during adolescence satisfies the increased demand of the organism for thyroid hormone very well.

In another period of physiological hyper-

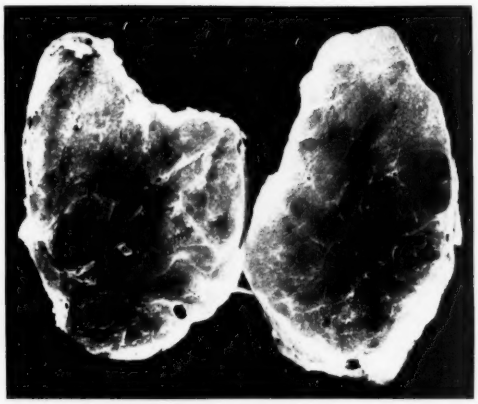


Fig. 1. Diffuse colloid goiter of 21 year old pregnant woman (autopsy specimen). Physiological during puberty and pregnancy, this form may persist and cause hyperthyroidism.

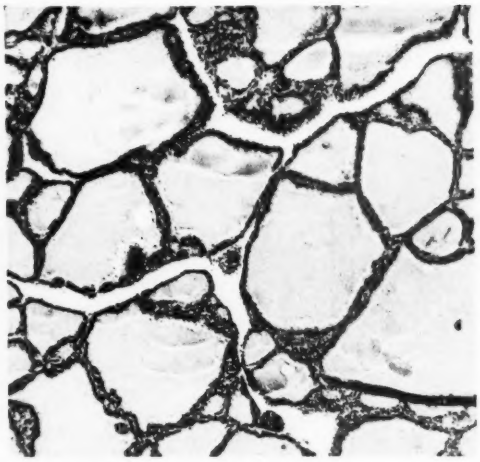


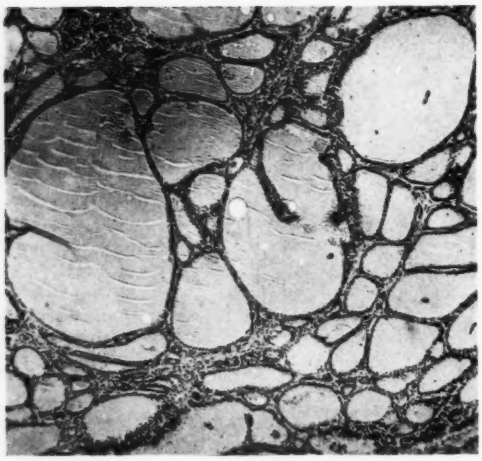
Fig. 2. Diffuse colloid goiter in 47 year old female. Clinical diagnosis was exophthalmic goiter.

thyroidism of pregnancy, we often see diffuse colloid goiter develop. It is, in my opinion, a successful attempt of the thyroid to produce more secretion. If the diffuse colloid goiter persists or develops after the twenty-fifth year, without pregnancy, then definite symptoms of hyperthyroidism are evident in the majority of cases (81 per cent).

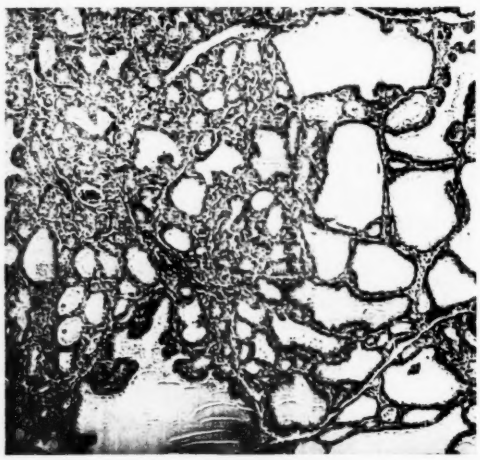
There is a close histological relationship between the diffuse colloid goiter and exophthalmic goiter. From the diffuse colloid goiter transition stages with higher and higher proliferation of the acinar wall lead finally to the classical picture of exophthalmic goiter. From my studies, not only of American, but also of European, material, I believe that exophthalmic goiter develops usually in a diffuse colloid goiter. Many exophthalmic goiters present on the cut surface either throughout or in patches an amber red and translucent appearance suggesting a colloid rich tissue. In nearly 85 per cent of the glands from patients with Graves' disease groups of lumina can be distinguished with the unaided eye. These lumina represent large colloid containing follicles such as one never sees in the normal gland, but which are characteristic of the duffuse colloid goiter. Microscopically, in over 90 per cent, areas with large colloid filled acini are noticed. That these changes are not due to an involution by Plummer's treatment is indicated by the fact that I saw them also in goiter material which was resected prior to the era of pre-operative lugolization.

Clinical and histological studies indicate therefore, that diffuse colloid goiter and exophthalmic goiter are two related stages of thyroid activity and that one can change into the other. Also comparative geographic studies

Fig. 3. Exophthalmic goiter of 42 year old male. No lugolization. The large visible follicles indicate that this exophthalmic goiter developed in a colloid goiter. Clinical diagnosis was primary exophthalmic goiter.



Figs. 4, left, and 5 are from different areas of the same goiter. The patient, a 22 year old female, had a typical Graves' disease and no history of long standing goiter.



The two photomicrographs show clearly that this exophthalmic goiter developed in a diffuse colloid goiter. This is my usual experience.

point to an association between both. A recent editorial of the *Journal of the American Medical Association* dealt with the comparative geography of toxic goiter. Attention was called to the discrepancy of Crotti's standpoint based on statistics of North American goiter and that of Saellstroem who examined the geographic distribution of thyrotoxicosis in Sweden. Crotti states that in this country exophthalmic goiter is associated with the distribution of simple goiter, while Saellstroem observed no correlation between these two thyroid diseases. I believe that Crotti and Saellstroem are both correct and that the different conditions in America and in Sweden are due to the different types of endemic goiter prevailing in these two countries. We know from our geographic studies, that in mountainous regions of severe endemicity, the parenchymatous colloid-poor goiter predominates; this type of goiter is hardly ever associated with toxic symptoms. In level regions, on the other hand, as in North America, the prevailing type is the colloid goiter. Colloid goiter is closely related to exophthalmic goiter, therefore thyrotoxicosis occurs in just those regions where colloid goiter is most common. From this fact we understand also, why Rice found only 3.9 per cent of toxic goiters in Berne, Switzerland, as compared with 87.5 per cent found in Minnesota.

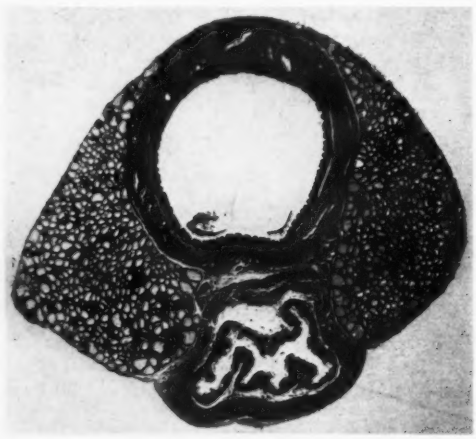


Fig. 6. Diffuse colloid goiter produced in the white rat by a calcium rich and iodine rich diet. It was not preceded by a parenchymatous goiter, but developed directly from the normal gland.

We may furthermore draw the conclusion that cretinism will never become a serious problem in our country as long as colloid goiter is the predominating type of endemic goiter.

The cause of goiter has been sought since the earliest days of medicine. Still the funda-

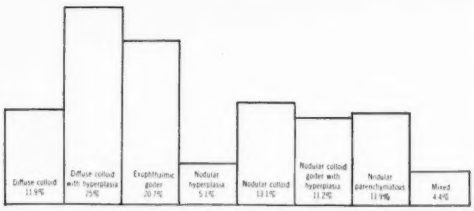


Fig. 7. The incidence of the different types of goiter in 276 surgical cases.

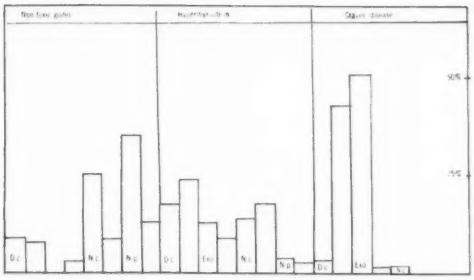


Fig. 8. Anatomical types of goiter in 276 surgical cases.

mental cause is unknown. The present view assumes that it is a compensatory hypertrophy of the thyroid due to iodine deficiency. While lack of iodine seems to play a certain rôle in the parenchymatous mountain type of goiter, the colloid goiter of level regions cannot be explained by it. Colloid goiter has never been produced in animals by a diet poor in iodine. I was unable to produce any type of goiter in white rats with an iodine-free diet. My results were confirmed by Hibbard and by Jackson. I believe therefore, that iodine deficiency by itself is not the essential cause of endemic goiter. There must be rather a positive goitrogenic agent. Calcium chloride proved in my experiments a very powerful factor in producing goiter. The structure of these experimental goiters varied according to the amount of iodine which was contained in the goiter-producing diet. An excess of calcium and, at the same time, a low content of iodine in the food caused parenchymatous goiter with very scanty colloid, while the same calcium-rich diet with a relatively high amount of iodine produced colloid goiter. By these experiments it was demonstrated that colloid goiter is not an involutionary stage of hyperplastic goiter, but a special form of endemic goiter, due to a positive goitrogenic factor with a relatively large amount of iodine.

Functional studies on experimental colloid goiter have never been made so far. Using as a measure of thyroid function the sensitivity of the goitrous animals to lack of oxygen, I found that colloid goiters produced by a calcium-rich and iodine-rich diet were much more active than the parenchymatous goiters produced by calcium-rich and iodine-poor diet. The experimental colloid goiters resembled in structure and function the human colloid goiters of the lowlands which are often associated with hyperthyroidism.

If our conception is right that the diffuse colloid goiter forms the anatomical basis for the development of exophthalmic goiter, we may expect that a successful prevention of colloid goiter will lead ultimately to the disappearance of Graves' disease. McClure believes that this result is already in sight. He reports that in Detroit, since the introduction of iodized salt not only has goiter in school children decreased, but also the number of operations for toxic goiter has been markedly reduced.

CONCLUSIONS

1. The diffuse colloid goiter is the prevailing type of endemic goiter in level countries.

TABLE I.—ANATOMICAL AND CLINICAL DIAGNOSES IN 276 GOITER CASES

Anatomical diagnosis	Cases	Per cent	Clinical diagnosis		
			Non toxic goiter	Hyperthyroidism	Graves' disease
Diffuse colloid goiter without hyperplasia	30	11.9	6	22	2
Diffuse colloid goiter with hyperplasia	69	25	5	30	34
Exophthalmic goiter	57	20.7		16	41
Nodular hyperplasia	14	5.1	2	11	1
Nodular colloid goiter without hyperplasia	36	13.1	18	17	1
Nodular colloid goiter with hyperplasia	28	11.2	6	22	
Nodular parenchymatous goiter "Fetal adenoma"	30	11.9	25	5	
Mixed nodular goiter (parenchymatous and colloid)	12	4.4	9	3	
Total	276	100	71 (25.7)	126 (45.7)	79 (28.6)

In North America, about 90 per cent of the surgical goiters develop in this structure.

2. The diffuse colloid goiter is not preceded, as a rule, by the parenchymatous, colloid-poor type of goiter, but it develops directly from the normal gland.

3. During puberty and pregnancy, a small diffuse colloid goiter is physiological. It satisfies the increased demand of the organism for thyroxin during these periods.

4. If the diffuse colloid goiter persists or develops after the twenty-fifth year of life and there is no pregnancy, symptoms of hyperthyroidism are very common.

5. There is a close anatomical relationship between diffuse colloid goiter and exophthalmic goiter. This explains the fact that toxic goiter is much more common in level regions where colloid goiter is the prototype of endemic goiter.

6. In white rats, diffuse colloid goiter can be produced by a diet containing a positive goitrogenic factor and a relatively large amount of iodine.

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CANCER OF THE BREAST

Prognosis in Surgically Treated Cases

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THE establishment of a satisfactory basis for prognosticating the clinical end-results in patients with cancer of the breast is a difficult undertaking because there are many variable factors which must be taken into consideration in arriving at a solution of the problem. Some of these factors are extremely complicated and difficult to evaluate, while others can be evaluated with a reasonable degree of precision.

It is well known that the natural course of the disease in individual patients is subject to the most extreme variations. In some patients a neoplasm of only a few months' known duration may progress rapidly to a fatal termination, while in others it may pursue a slow, insidious course for years, producing comparatively insignificant disability. This fact suggests that there might be something of a biological or constitutional nature which determines the ability of the patient to resist the disease, or that the neoplasms differ in the degree or intensity of their malignancy.

There are no simple standards by which to measure and to express objectively the possible influence of biological or constitutional factors upon the prognosis, but there are simple and rather satisfactory methods of objectively recording the malignant potentialities of neoplasms so that these may become the basis for prognosis.

The prognosis is very materially affected by the type of growth, of which there are several having rather distinctive features with regard to their mode of development, their histological characteristics, their rapidity of growth, and their dissemination. Prognosis in carcinoma of the papillary and Paget's types is distinctly more favorable than in the more frequently encountered carcinoma of the female breast not having these distinctive features. On the other hand, it is less favorable in the so called sweat gland cancers and cancers of the male breast. Sarcoma is of comparatively infrequent occurrence, and the prognosis is relatively good, particularly for those sarcomas having their origin in pre-existing, benign, periductal adenofibroma. Nevertheless in certain instances, highly undifferentiated or anaplastic sarcoma of connective tissue or lymphoblastic type may pursue a rapidly fatal course.

Not only is there a difference in the prognosis among the different types of growth, but for each type there are extreme variations in individual instances, due in part to qualities inherent in the tumor and in part to accidental circumstances.

Fundamentally, histological grading may be taken as an index of the inherent malignancy of the growth and no doubt would be a proper basis for prognosticating the probable rapidity of progress of the neoplasm in terms of life expectancy, in cases which run their natural course untreated. But the degree of malignancy as indicated by histological grading *per se* is not the most important factor in determining the curability or incurability of the cancer. The latter are more definitely and significantly related to the degree of localization or dissemination of the growth. It is for this reason that we believe that the extent and character of involvement are more important than the histological grading from the standpoint of prognosis.

To some extent it is an accidental matter whether the dissemination of the cancer is limited to the regional lymph nodes or is more widely dispersed to the intrathoracic viscera, the intra-abdominal viscera, the cranial organs, or to the osseous system. The spread of the cancer to any of these localities, other than to the most proximate regional lymph nodes, renders the condition incurable in so

From the Cleveland Clinic.

Trimble Lecture, read before the Medical and Chirurgical Faculty of the State of Maryland, Baltimore, Maryland, April 28, 1936.

far as our present therapeutic accomplishments are concerned. In contradistinction to the incurability of the cancer, the duration of life or longevity is determined not so much by the fact of dissemination as it is by the localization of the secondary deposits. Thus, metastases to the osseous system may be not incompatible with prolonged life, whereas metastases to the lungs or brain materially curtail life expectancy.

The foregoing considerations, all of which materially influence the natural course of the disease and the prognosis quite apart from any question of treatment, cannot be ignored in any study designed to evaluate the comparative merits of different forms of treatment. As to what constitutes adequate, efficient or even appropriate treatment, there appears to be a diversity of interpretation.

Whatever the form of treatment employed, whether by surgical operation, by irradiation alone, or by the two forms combined, the fundamental principle governing the treatment is perfectly clear, namely, that the tumor should be completely removed or completely destroyed while it is still confined to the breast or to accessible tissues. This is the *sine qua non* for success. It is the practically universal experience that when the neoplasm has spread beyond these prescribed limits, the prospects of a definitive cure are practically nil.

The following discussion is not concerned with the question whether or not all patients with operable cancers of the breast should be treated surgically, or whether none should be so treated, the alternatives being radiation therapy only or irradiation combined with surgical treatment. For the purposes of this paper, it is assumed that a diagnosis of cancer has been made or that such a lesion is strongly suspected, and that an operation is to be performed.

With regard to the question of diagnosis, I cannot do better than to quote from a paper by J. M. T. Finney: "When a woman consults a surgeon for a lump in her breast, one question and one only, of paramount importance, at once presents itself to the surgeon for answer, namely, 'Is this lump cancer or is it not?' All other questions but this one can await an answer. This one cannot, and until it has been answered beyond all question of doubt, the first duty of the surgeon to his patient will not have been discharged." With this dictum the writer is in hearty accord.

It is beyond the scope of this paper to enter into a discussion of the intricacies of making a diagnosis, but the necessity for so doing is emphasized. It is true that, in the majority of cases of cancer of the breast, an experienced clinician can make the correct diagnosis with little difficulty at the first examination. There is, however, a small percentage of cases in which there is no possibility of the most experienced clinician making a correct diagnosis by external examination. It is precisely in this group of cases that the utmost clinical judgment, skill, and finesse are required to the end that the patient's welfare be not jeopardized. It is precisely in this group that avoidable catastrophes occur owing to inappropriate advice or treatment. It is precisely in this group that the question of biopsies arises to torment the surgeon.

Biopsies as diagnostic procedures should be reduced to a minimum; nevertheless they should be performed, should the occasion arise, provided arrangements have been made for immediate radical amputation in the event a positive diagnosis is established by gross examination or by frozen section. Excision of a local tumor is preferable, keeping well beyond its margins, or simple mastectomy may be performed, particularly when the breast is more or less diffusely involved by an involutional or cystic process, which in itself is an indication for mastectomy quite apart from the question of cancer. And finally, in certain selected cases, it might be deemed advisable to make an exploratory incision directly into the tumor. Our experience has been that local excision of the tumor and simple mastectomy have not appreciably increased the hazard; with regard to the exploratory incision, there is a distinct reservation.

Although a surgical operation has been the most important form of treatment employed in the series of cases here considered, the details of surgical technique will not be discussed. Thanks to the pioneer work of the late Dr. William S. Halsted, the technique of radical amputation has been sufficiently

well established and standardized and is sufficiently well known among surgeons to render its further discussion unnecessary. Varied as may be the minutiæ of the actual operative procedure in the practice of different surgeons, there is or should be one common objective—complete removal of the cancer, with minimum residual disability. To keep out of the growth and beyond the limits of its spread should be the constant endeavor of the surgeon during the operation.

A short digression may be permissible for the purpose of making certain observations concerning the extent of the operative procedure in *groups* of cases. In a small percentage of cases, simple mastectomy is adequate treatment *provided the entire breast gland is removed.* Needless to say, these are cases of cancer in the incipient stages in which the process has not progressed to the formation of a gross tumor nodule. For years it has been our rule to be content with simple mastectomy in the absence of a gross tumor nodule in the breast and there has been no occasion for regret. This rule, however, presupposes a thorough and competent gross examination of the breast immediately after its removal. If no gross tumor is demonstrated, one need not be disturbed by a diagnosis of cancer made on a frozen section or a paraffin section. In all such cases in our experience the patients have remained cancer free. It should be emphasized that this rule should be absolutely abrogated unless one can rely upon the thoroughness and competence of the gross examination of the breast.

On the other hand when a gross cancer is present, the breast and axillary contents should be removed with or without removal of the pectoral muscles, depending upon the circumstances of the individual case and the ability of the surgeon to remove the axillary glands without sacrifice of pectoral muscles. That an amputation of the breast and axillary dissection without removal of the pectoral muscles is adequate treatment for a certain group of patients has been proved to our entire satisfaction.

In a third, more advanced but still not obviously incurable group, the amputation should include axillary dissection and removal of pectoral muscles and is the classical procedure.

In a fourth and even more advanced group of cases, it would appear that a great deal of futile surgery and useless sacrifice of tissue has been practiced. A specific instance of such is that of a patient in whom it had been demonstrated that there were widespread osseous (pelvic) metastases. Within a few weeks thereafter, this patient was subjected to an extremely radical amputation of the breast, and there was not even the excuse of an impending ulceration to warrant such an extensive procedure. Patients in this advanced group are incurable at the time of operation and the removal of a few more centimeters or even inches of tissue with the breast safeguards the patient little or not at all. Indeed it is a question worthy of serious consideration whether or not the surgical intervention may not hasten the spread of the cancer in some of these patients. Predictions are hazardous; nevertheless, I am disposed to believe that when surgeons get around to a more serious consideration of the class of patients now under discussion, they will be tempted to operate upon fewer of them, because it is too late.

Some of the foregoing statements concerning the extent of operative procedure for groups of cases may appear to be startling and unorthodox. Their justification, however, is to be found in a comprehensive understanding of the pathology of cancers of the breast. The operative procedure itself, and likewise the prognosis and end-results, are subject to the pathological considerations incident to each case. Any surgeon can cure a cancer of the breast when the cancer is confined to the breast, the only requirement being to remove it and keep out of it while doing so. No surgeon can cure a cancer of the breast when it has spread beyond the tissues he can remove. Therein lies the key to the problem of prognosis and end-results in surgically treated patients, modified as these will be by the celerity, dexterity, and conscientiousness with which the surgeon executes the operative procedure.

To what extent radiation therapy, whether by means of roentgen-rays or by radium, and

whether administered before, after, or both before and after operation, will modify the prognosis or end-results in surgically treated patients is a matter which will be determined by future observations and experience. This may be said however,—irradiation which cannot be relied upon to keep the cancer confined to the breast and which cannot be relied upon to prevent its spread cannot be considered efficient or adequate from the standpoint of cure. The catastrophe would be to allow an early cancer to become advanced, a curable cancer to become incurable. Therein lies the hazard of inadequate irradiation, which is no less a menace than is inadequate surgery.

Moreover, before preventative or curative action can be claimed for the irradiation which is utilized in conjunction with the surgical operation, it must be shown that there is a distinct improvement in the clinical end-results over and above that which is properly attributable to the operation alone. In our own experience this very desirable accomplishment has not been achieved in so far as we have been able to determine from a critical analysis of a series of patients treated by operation, with and without irradiation, during the years 1896 to 1930 inclusive. An article presenting the data derived from that analysis has been published in the *Pennsylvania Medical Journal* (2).

A METHOD OF GROUPING FOR PROGNOSTIC PURPOSES

As a result of investigations carried out during the past 5 years, there has evolved a grouping of surgically treated cases of cancer of the breast, based upon the character and extent of involvement at the time of operation which permits a reasonably reliable prognostication of the clinical end-results well in advance of the 3, 5, and 10 year follow-up periods.

The grouping to be described is founded upon the conception that cancers of the breast are curable when they are confined to the breast gland, and that they become progressively less curable in direct relationship to the degree of spread or dissemination. And, finally, when they have spread beyond the tissues which a surgeon can remove by a meticulously executed operation, they are frankly incurable from a surgical standpoint.

The differentiation of the groups is dependent upon a correlation of clinical and gross pathological findings, *after removal of the breast.* The grouping is, therefore, of prognostic rather than of diagnostic interest. It is in no way related to the histological grading of tumors in the usual acceptation of the term. It is in no way designed to question the validity of histological grading nor to replace it. However, it might very well serve as a check upon the latter.

The designation and definition of the groups is as follows:

Group I. This group includes cases in which a histological diagnosis of cancer is made in the absence of a gross tumor in the breast. The axillary nodes in these cases are presumed or proved to be uninvolved.

The writer would be disposed to apologize for the inclusion of this group were it not for the improbability of a unanimity of opinion among pathologists as to the nature of the lesions and the inevitability of a diagnosis of carcinoma by some observers. Therefore, these lesions cannot be ignored. However, they should be segregated into a group in order that they may be accepted or rejected at the discretion of those interested.

The lesions in this group are not frank cancers, yet an unequivocal diagnosis of benignancy cannot be made. The important point is that simple mastectomy is adequate treatment.

Group II. A localized carcinoma in the breast, without involvement of the axillary nodes, and with none of the signs of "incurability" noted under group IV.

It is presumed that the neoplasms in this group are comparatively early and are favorable for treatment. Consequently, all the known facts of the case must be consistent with this hypothesis. For example, a patient who knows of the existence of a cancer in the breast for several years cannot be considered to have an "early" lesion, even though the tumor is local in the breast and the axillary nodes prove to be uninvolved on microscopic examination.

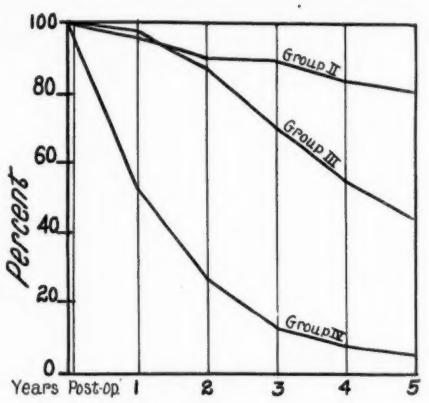

Fig. 1. The percentage of patients in groups II, III, and IV known to be alive at the end of 1 to 5 years with or without clinical evidence of cancer.

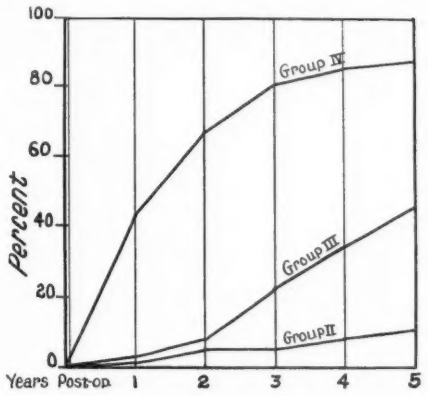

Fig. 2. The percentage of patients in groups II, III, and IV who died in 1 to 5 years, irrespective of the cause of death.

Since the absence of involvement of the axillary nodes is the chief basis of differentiation for this group, it must be apparent that there will be a certain error in classification, owing to the fact that metastasis may occur through routes other than the axillary nodes. Tumors situated in the upper inner quadrant are particularly prone to metastasize to localities other than the axillary nodes.

Theoretically, complete removal of the breast gland with the nipple and adjacent skin would be adequate treatment. However, radical amputation most certainly should be recommended for every patient who has a gross cancer in the breast, provided the operation is undertaken for cure.

Needless sacrifice of muscle and extensive excisions of skin are not required and are probably not justifiable, unless the surgeon feels that he cannot properly perform the operation otherwise.

Group III. A localized carcinoma in the breast, with early or moderate metastatic involvement of the axillary nodes, and without the signs of "incurability" noted under group IV.

The tumors in this group are moderately advanced and are selected by elimination. If they do not properly belong in groups I, II, or IV, they are placed in this intermediate group.

The outlook is not predictable for individual patients in this group. The best that can be hoped for is to arrive at a reasonably reliable prognostication of the average end-results for a series of cases.

Radical amputation is indicated whenever the operation is undertaken for cure and is the classical procedure.

Group IV. A case in which the patient has a carcinoma in the breast and has any one or any combination of the following signs of "incurability": (1) Infiltrating or diffuse carcinoma; (2) secondary nodules in the breast; (3) secondary involvement of the muscle or skin (not simply dimpling over the tumor); (4) diffuse edema of the breast or skin, not obviously of inflammatory nature; (5) extensive axillary metastases; (6) metastases to the supraclavicular nodes or to distant parts.

This group also includes cases in which purely palliative operative procedures are undertaken.

It has been our experience that the results are uniformly bad in this group.

RESULTS IN SURGICALLY TREATED PATIENTS, GROUPED ACCORDING TO THE EXTENT OF INVOLVEMENT AT THE TIME OF OPERATION

The data to be presented have been derived from an analysis of all cases of unilateral and bilateral cancer occurring in the female breast, in which patients have been operated upon primarily by four surgeons of the Cleveland

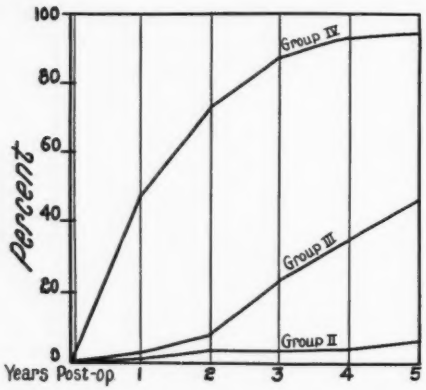

Fig. 3. The percentage of patients in groups II, III, and IV in whom clinical evidence of cancer developed post-operatively, in 1 to 5 years.

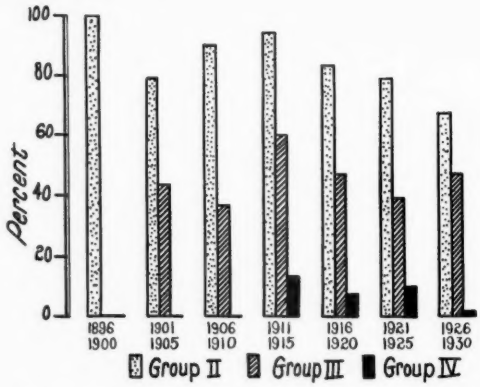

Fig. 4. The percentage of patients in groups II, III, and IV who lived 5 years or more, arranged in successive 5 year periods from 1896 to 1930.

Clinic, during the years 1896 to 1930 inclusive.

Excluded from consideration are all cases of sarcoma and carcinoma of the papillary, Paget's and so called sweat gland type, as well as those cases which could not be classified on account of inadequate records.

The follow-up is based upon the latest information available in March 1936.

The end-results of treatment in the individual groups previously defined and for the total classified are briefly summarized in Table I and in Figures 1 to 5.

The criteria used are as follows: the comparative data relative to groups I to IV and the total cases classified are included in Table I. This shows the number of patients operated upon; the number and percentage of traced patients; the percentage incidence of the individual groups in relation to the total classified, and the clinical end-results as indicated by the percentage of patients who survived 5 years or more; the percentage of patients in whom clinical evidence of cancer developed in less and more than 5 years; the percentage who remained cancer free during the follow-up of less and more than 5 years; the percentage who died of cancer in less and more than 5 years; the percentage of deaths due to cancer in the individual groups and the total, and the average years of known post-operative survival.

One patient in group I has been followed more than 20 years, 4 were followed more than 15 years, 2 for more than 10 years, and the 5 others for $2\frac{1}{2}$, 3, 5, 6, and $7\frac{1}{2}$ years. All have remained cancer free. If these 12 cases, which are not frank cancers, were eliminated from the table, the net result for the remaining 533 would be changed by less than 2 per cent.

The results in groups II, III, and IV are quite sharply differentiated, in so far as can be judged by the criteria set forth in the table which is self explanatory. The results for the total cases classified approximate those generally reported in current literature.

The alarming fact is that 40.7 per cent of the traced patients were practically incurable (group IV) when operated upon, and in only 31.8 per cent was the local condition such as to justify the hope of a high percentage of cures (groups I and II). The general indications are that in only about one-third of group III patients does there appear to be a possibility of cure. It is not without interest to note that the results in group III rather closely approximate the results shown for the total cases classified. For this reason varying proportions of group III have less influence upon the net results for a series of cases than do varying proportions of groups II and IV, the former tending to decrease the morbidity and the mortality while the latter tends to increase both.

TABLE I.—COMPARATIVE DATA RELATIVE TO THE INDIVIDUAL GROUPS AND TO THE TOTAL CLASSIFIED

	Group I	Group II	Group III	Group IV	Total
Number of patients operated upon	12	179	161	288	640
Traced cases	12	161	150	222	545
Per cent	100.0	90.0	93.3	77.1	85.2
Group incidence of traced cases, per cent	2.2	29.6	27.5	40.7	
Survived 5 years, per cent	75.0	80.2	44.0	5.4	39.6
Cancer positive after operation, per cent					
Less than 5 years	0.0	5.0	46.0	93.6	52.3
More than 5 years	0.0	9.9	20.7	5.0	10.7
Cancer free after operation, per cent					
Less than 5 years	25.0	14.9	10.0	0.9	8.1
More than 5 years	75.0	70.2	23.3	0.5	28.9
Dead of cancer, per cent					
Less than 5 years	0.0	5.0	42.7	87.3	48.8
More than 5 years	0.0	0.8	14.0	4.5	7.7
Deaths due to cancer. Before and after 5 years, per cent	0.0	42.2	89.5	100.0	89.5
Known postoperative survival, average years	10.8	10.2	5.2	1.7	5.5

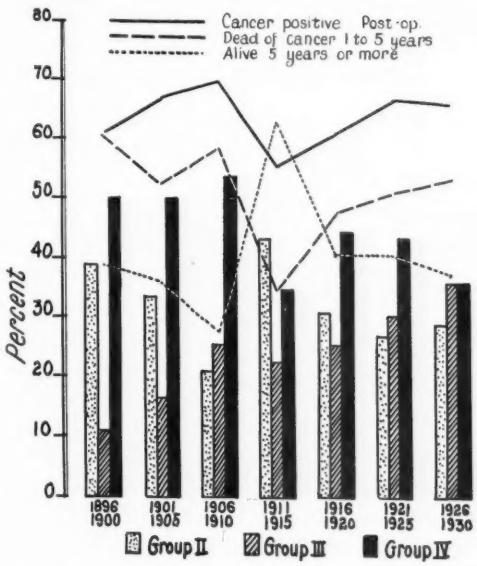

Fig. 5. The percentage of patients (dead and alive) in whom clinical evidence of cancer developed before and after 5 years after operation; the percentage dead of cancer in less than 5 years; and the percentage alive 5 years or more—in relation to varying proportions of patients in groups II, III, and IV treated in the successive 5 year periods from 1896 to 1930. All percentages in this table are calculated upon a basis of 533 cases which is the total remaining after exclusion of 12 group I cases.

To what extent the apparent incurability of group IV cases may be recognized clinically is a problem for future consideration.

Figures 1, 2, and 3 show, respectively, the percentage of patients in groups II, III, and IV who were known to be alive with or without cancer, the percentage known to have died of all causes, and the percentage who had persistence of cancer (incomplete eradication or distant metastasis) or who developed clinical evidence of recurrence or metastasis at the end of 1 to 5 years. From these three standpoints, the graphs show a striking differentiation of groups II, III, and IV and clearly indicate the relative malignancy (curability or incurability) of the groups.

On the basis of the information available at present, were we to continue the lines in Figure 3 to a 10 year follow-up (which is not legitimate for the majority of patients operated upon after 1925) the results would be: 97.8 per cent of group IV, 62.0 per cent of group III, and 10.5 per cent of group II have shown evidence of persistence of the cancer—in other words have not been cured.

That the clearly defined differences in the results for groups II, III, and IV shown in the table and graph are not purely accidental nor coincidental is indicated by the comparative uniformity of the results for the individual groups in the seven successive 5 year intervals from 1896 to 1930. This is depicted in Figure 4, the percentage of 5 year survivals being used as a criterion. The same comparative uniformity obtains when all the other criteria utilized in the preceding table and graph are applied.

The data depicted in Figure 5 illustrate graphically the interdependence of the results upon the relative proportion of favorable (group II) and unfavorable cases (group IV) entering into the total number of patients treated during the successive 5 year intervals from 1896 to 1930. There is a distinct parallelism between the horizontal curve which indicates the percentage of patients in whom evidence of cancer developed after operation and that which indicates the percentage who died of cancer in less than 5 years. These two curves may be taken as rough indicators of

the unsuccessful results and the height of these curves is determined chiefly by the proportion of group IV cases treated. There is an inverse relationship between these two curves and that which indicates the percentage of patients who lived 5 years or more after operation, and which may be taken as a rough indicator of the successful results. The height of the curve for 5 year survivals is determined chiefly by the proportion of group II cases treated. Attention is directed particularly to the 1911–1915 cases. During this interval the percentage of 5 year survivals was 62.5 per cent which is in conformity with the fact that the proportion of group II cases was distinctly higher in this than in any other 5 year interval. At the same time the proportion of group IV cases was less in this than in any other 5 year interval and is largely responsible for the fact that the percentage of patients who died of cancer in less than 5 years and the percentage in whom evidence of cancer developed after operation are lower in this than in any other interval. These relationships are strikingly uniform throughout. When the proportion of group II cases is high, the results for the total number of patients treated are comparatively good. When the proportion of group IV cases is high, the results for the total treated are distinctly not good.

EVALUATION

It is apparent from an examination of the table and graphs that, from the standpoint of the "curability" or "incurability" of the cancers, the differentiation of the individual groups is quite well defined. From a consideration of the pronounced disparity in the end-results in the individual groups, it must be obvious that the average end-results for different series of cases will be affected very materially by variations in the relative proportions of patients in the curable (groups I and II), incurable (group IV), and intermediate (group III) groups entering into the totals.

Variations in the relative proportions of favorable and unfavorable cases more than any other factor account for the extreme differences in end-results reported from surgical clinics in this country and abroad, based upon tabulations of 5 year survivals. Before statistical analyses of the results from different clinics or for different forms of treatment can be compared, there must be some method of arriving at an equalization of the relative proportions of early and late cases treated.

Whether or not the method of grouping here suggested is superior to histological grading or other methods in vogue is of less importance than is the recognition of the necessity of utilizing a *readily applicable and acceptable method.*

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CLINICAL AND LABORATORY FINDINGS AFTER EXCESSIVE LOSS OF INTESTINAL FLUID FROM THE ILEUM

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IN THE presence of intestinal fistula or diarrhea the loss of salt and water from the body through the alimentary dejecta is inevitable. This loss of salt and water is usually compensated for by a decreased urinary excretion or a liberal intake of these substances. However, at times, the loss of salt and water through an intestinal fistula or in severe diarrhea is so great that the compensatory mechanisms are not capable of preventing depletion of these important constituents of the body. When depletion of water and salt occurs, grave clinical emergencies may ensue. It is the object of this report to record the clinical and laboratory findings in a case in which there was an excessive loss of salt and water through an ileac stoma after an ileostomy had been performed. The excessive loss of salt and water was followed by a syndrome not unlike that seen during the crisis which occurs in the course of Addison's disease. In the latter condition the symptoms which occur during a crisis are known to be caused by an excessive loss of sodium and chloride through the urine. This loss is the result of the absence of the normal suprarenal control which seems to regulate the excretion of these substances (6).

REPORT OF CASE

A man, aged about 30 years, had had a chronic diarrheal disease, which had been characterized by ulceration of the colon and subsequent healing, with marked deformities in the lumen of the colon. The distal few inches of the terminal portion of the ileum also were deformed. Preliminary to a more formidable procedure, an ileostomy was performed close to the ileocecal juncture. The postoperative course was uneventful for 10 days; although the excretion of fluid from the ileac stoma was considerable, there were no untoward symptoms. On the eleventh day after operation, the chemical examination of the blood did not reveal any change except for a decrease in the value for the chloride in the plasma (Fig. 1). The value for the chloride, expressed as sodium chloride, was 553 milligrams per 100 cubic centimeters of plasma, the value for the carbon dioxide combining power was 54.1 volumes per 100 cubic centimeters of plasma, and there were 24 milligrams of urea in every 100 cubic centimeters of blood. On the morning of the fifteenth postoperative day, the patient complained of weakness, nausea, and chilliness; he also was drowsy. There had been considerably more loss of fluids from the ileum in the preceding 24 hours than there had been previously. His oral temperature was 97 degrees F.; the pulse was small and weak, and its rate was 80 beats per minute. The value for his blood pressure, expressed in millimeters of mercury, was 70 for the systolic and 50 for the diastolic, whereas it previously had ranged around 110 for the systolic and 70 for the diastolic. The blood, when drawn from a somewhat collapsed vein, was dark, although the patient was not cyanotic. There was a larger volume of celis than serum in the centrifuged specimen. The value for the carbon dioxide combining power was 36.2 volumes per 100 cubic centimeters of plasma, the value for the chloride was 528 milligrams per 100 cubic centimeters of plasma, and there were 56 milligrams of urea in every 100 cubic centimeters of blood (Fig. 1). There were 310.5 milligrams of sodium and 20.4 milligrams of potassium in each 100 cubic centimeters of serum. Intravenous infusions of physiologic saline solution and dextrose were given and sodium bicarbonate was administered by mouth. After the institution of these measures, marked symptomatic improvement occurred and the blood pressure returned to its previous level. Subsequent to this episode, this patient was given sodium chloride and sodium bicarbonate orally; there was no return of a similar episode and the value for the systolic blood pressure remained higher than 90 millimeters of mercury. Four days after the institution of this regimen, chemical examination of the blood gave satisfactory results (Fig. 1). Thus, on the nineteenth day after operation, the value for the carbon dioxide combining power was 64.9 volumes per 100 cubic centimeters of plasma, the value for chloride (expressed as sodium chloride) was 569 milligrams per 100 cubic centimeters of plasma, and there were 16 milligrams of urea in every 100 cubic centimeters of blood. Examination of the blood on the twenty-third day after operation gave satisfactory results.

From the Mayo Foundation and Mayo Clinic.

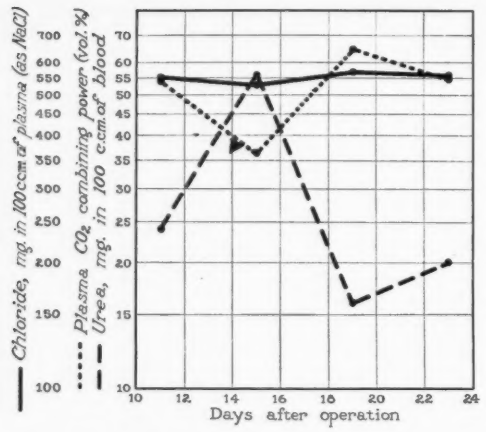

Fig. 1. Chemical composition of blood after ileostomy.

OBSERVATIONS

We would like to point out the fact that under ordinary circumstances an ileac stoma is compatible with normal physiologic economy. In support of this statement we shall present some data obtained from a study of another patient who had undergone an ileostomy. In this case the patient was a young woman who was in the hospital where metabolic studies could be made and the intake of food, fluid, and salt could be regulated. Analysis of excreta (urine and ileac dejecta) showed certain variations from the normal values, especially in the excretion of sodium chloride.

In Table I we have recorded some data obtained by analysis of food, urine, and ileal dejecta for sodium chloride in one of several periods of controlled, normal existence. With these results, we have tabulated the expectancy of the value of these same substances in the urine and stools of a normal individual who had an intact gastro-intestinal tract, and who received the same amounts of food, fluid, and salt. Examination of these figures reveals that one normally may expect approximately 2 per cent of the total output of sodium (exclusive of losses by skin) to be eliminated through the gastro-intestinal tract and 98 per cent by way of the urine. The young woman who had undergone an ileostomy eliminated approximately 91 per cent of the total output of sodium through the gastro-intestinal tract and 9 per cent in the urine. This is almost a complete reversal of the normal condition. In the elimination of chloride one normally expects no more than about 2 per cent in the feces and the rest in the urine, but this patient eliminated 27 per cent of the total chloride through the intestinal tract. It is apparent from these data that the loss of fixed base (sodium) from the ileum of this patient was relatively greater than that of fixed acid (chloride). This patient's health was excellent and the necessary retention of sodium would account for loss through the skin. The principal factors responsible for the ability which she demonstrated to maintain normal serum electrolyte in the face of losses of base from the ileum were an adequate intake of minerals in the food and the presence of the excellent mechanism which the body possesses for preservation of the total electrolyte of the fluids of the body, which Kendall and others have said may depend to some extent on the action of the hormone produced by the suprarenal gland. It is interesting to note that only 0.13 gram of sodium was eliminated in the urine during 24 hours, which demonstrates the extent to which this compensatory action may be exerted.

Since a large part of the dejecta from the ileum is fluid, we felt that an examination of this portion, separated from the solid constituents, would be interesting. Accordingly, the total dejecta were centrifuged and filtered. The filtrate then was analyzed. In Table II we have recorded the values obtained for 2 specimens of such fluid, taken on different occasions when the patient had been consuming food at regular intervals. Sodium was the predominant base and its concentration was near that of blood serum and unadulterated succus entericus; the concentration of potassium is low in these fluids. In the fluid obtained from the ileac stoma on these occasions, however, the concentration of calcium was higher than that found in blood serum or succus entericus, with a corresponding rise in the concentration of inorganic phosphorus, but it is interesting to note that, except for this deviation, the effect of alimen-

TABLE I.—DISTRIBUTION OF TOTAL DAILY OUTPUT OF SODIUM AND CHLORIDE IN URINE AND INTESTINAL EXCRETION

	Subject with an ileostomy		Expectancy for a normal subject	
	Grams	Per cent	Grams	Per Cent
Intestinal excretion				
Sodium	1.32	90.9	0.029	2.0
Chloride	0.73	27.1	0.05	2.0
Urine				
Sodium	0.13	9.6	1.16	98.0
Chloride	1.96	72.9	2.64	98.0
Intake				
Sodium	1.74		1.74	
Chloride	3.06		3.06	
Output				
Sodium	1.45		1.45	
Chloride	2.69		2.69	

TABLE II.—COMPOSITION OF CERTAIN FLUIDS OF THE BODY

	Fluid component of dejecta from lower portion of human ileum (two specimens) Mg. per 100 c.cm.		Human blood
	1st specimen	2d specimen	Mg. per 100 c. cm.
Sodium	305	284	330*
Potassium	18	19	20*
Calcium	50	33	10*
Magnesium	19	19	3*
Inorganic phosphorus	19	22	4*
Chloride	283	300	360†

*In serum.
†In plasma.

tation did not cause any great differences between this supernatant fluid of the stool and uncontaminated succus entericus. The concentration of chloride in the dejecta from the ileum was lower than that in blood serum and similar to that of the secretion of the ileum of dogs (2). These data, then, suggest the reason for the larger elimination of sodium than chloride in the total ileal dejecta, which is recorded in Table I. Great losses of fluid from the ileum of man, if unreplenished, would result in a greater depletion of fixed base than of acid.

The production of dehydration and acidosis after losses of fluid from the ileac stoma and the train of resulting symptoms have been observed frequently in various experimental and clinical states in which losses of the intestinal fluid have been great. O'Shaughnessy recognized acidosis in cases of severe cholera in 1832. Howland and Marriott, Schloss and Stetson, and others have reported acidosis with severe diarrhea in infancy. Hartmann and Elman have demonstrated that continuous loss of pancreatic juice in dogs results in dehydration, acidosis, and death in about 8 days. In their studies death was preceded by a uniform group of symptoms: loss of appetite, weakness, and drowsiness.

The explanation of the production of acidosis after the continuous loss of intestinal fluids rests with the knowledge of the composition of these secretions. Gamble and McIver have found that pancreatic fluid contains fixed base in approximately the same concentration as that in the blood plasma and sodium is the chief base of both. In pancreatic juice, however, only a fourth to a half of the fixed base was found to be represented by the chlorine ions, the remainder being associated with the bicarbonate ions. Thus, with the loss of pancreatic juice, relatively less fixed acid than fixed base will escape from the body. DeBeer, Johnston, and Wilson, who recently have examined the composition of intestinal fluid of dogs, found a great similarity between the succus entericus throughout the intestinal tract. The concentrations of sodium, potassium, and calcium are relatively constant in jejunal, ileac, and colonic secretion and are like that in blood serum. The concentrations of bicarbonate and chloride, however, show marked reciprocal variations, the concentration of bicarbonate is high and that of chloride is low in ileac and colonic secretions, which are more alkaline than are jejunal juices, an observation previously recorded by Mann and Bollman. The studies by Karr and Abbott on human intestinal secretions at various levels of the intestinal tract have shown the same relative relation between base and acid in the intestinal fluids of man. In the case of the patient studied under controlled metabolic conditions (Tables I and II), we have studied the fluid portion of the dejecta from the ileum, which also contained more fixed base than acid.

Bile, the other important fluid which drains into the intestinal tract and which in some cases is subjected to continuous loss, would be less likely to disturb the bicarbonate of the blood serum since the greater part of its base

is combined in the chloride as is true of blood serum (4).

The conditions observed among dogs after the loss of pancreatic juice are identical with those seen in the study we have described. They are the symptoms produced by the loss of water and base and are seen in certain types of shock, at times are present in severe diarrhea, and are most widely associated with Addison's disease (12), in which the loss of sodium and chloride occurs through the kidney. The effects of the loss of an excess of base from the intestinal tract may be successfully combated by the administration of sodium chloride and sodium bicarbonate. The administration of sodium chloride alone is a less rational procedure than is the administration of sodium chloride and sodium bicarbonate, since the former supplies considerable fixed acid to an organism which already possesses acid in excess over base; this necessitates a considerable adjustment. If compensation is not accomplished, a hyperchloremia may be the result. In supplying sodium bicarbonate, the conditions necessary for remedying a deficit in fixed base are more adequately attained—an observation which Hartmann (7) has made in a study of infantile diarrhea.

Losses of gastric juice, unlike those of intestinal fluid, produce a state of alkalosis and dehydration, which is the result of the loss of water and a relative excess of chlorine ions over basic ions, as has been demonstrated experimentally by many investigators (1, 3, 5). The effect of such losses frequently is seen clinically and is demonstrable in the blood by a considerable decrease in the concentration of chloride in the plasma and by an increase in the carbon dioxide combining power (14) of the plasma. This condition, the reverse of that produced by loss of intestinal secretions, is explained on the basis of the composition of combined gastric secretion, which contains an excess of fixed acid over base. It would seem that the loss of intestinal fluid from the more distal part of the small intestine, when this loss cannot be compensated for by an adequate intake, will produce a more extensive depletion of the basic ions with a resulting acidosis than is observed with comparable losses of fluids from proximal segments of the small intestine. Loss of fluid from the more proximal portions of the intestinal tract, such as occurs in cases of duodenal fistula, may result in alkalosis, as Walters, Kilgore, and Bollman have demonstrated, because the fluid which escapes is in reality gastric juice.

SUMMARY

The subjective and objective symptoms of excessive loss of fluid that contains an excess of base over acid are uniform irrespective of the fundamental mechanisms which are disturbed. The symptoms are loss of appetite, weakness, drowsiness, concentration of the blood, and a low blood pressure.

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RESISTANCE OF THE SPHINCTER OF ODDI IN THE HUMAN

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SINCE its description in 1880 by Oddi, the sphincter of the common bile duct has received a great deal of attention both from experimental workers and clinicians. Animal investigations have shown that the resistance of this sphincter is greatly modified by various conditions such as the irritation of the gastric mucosa, the distention of the stomach, starvation (6), local irritation of the sphincter by acid (1, 14), and stimulation of the autonomic nervous system. The sphincter is relaxed through action of the sympathetic system and is thrown into spasm by the parasympathetic innervation. Since the nervous control of sphincters is very complex, these results are often inconstant. Drugs acting directly on smooth muscle and causing spasm increase the resistance of the sphincter, while drugs which reduce the tonicity of smooth muscle produce relaxation of the sphincter in animals (3, 4, 10, 12, 17). The consensus is that the sphincter of Oddi, *per se*, can act independently. The duodenal musculature which embraces the common bile duct as it obliquely penetrates its wall, probably influences the resistance of the sphincter of Oddi (7).

The literature is replete with clinical observations regarding the relationship of the sphincter of Oddi to such conditions as acute pancreatitis (1), post-cholecystectomy syndrome (16, 18), the dyskinesias of the biliary tract (9), and various forms of jaundice (13). Recent observations by means of lipiodol injections have clearly demonstrated that spasticity of the sphincter of Oddi occurs in humans (2).

However, there have been very few references to the actual measurement of the resistance of the human sphincter to the flow of fluid into the duodenum. Aside from some observations of Pribram, and of the report of Butch and McGowan, no records are available, either of the resistance of the normal human sphincter, or its variations under pathological conditions.

This report is concerned with the measurements of the resistance of the sphincter of Oddi obtained in patients who have had a T-tube intubation of the common bile duct. A method was developed for the kymographic recording at the bedside of the resistance of the sphincter to the flow of fluid into the duodenum. Advantage was taken in these cases to observe the effect of local application of drugs to the periampullary region of the duodenum and of hypodermic injections of the various drugs commonly used in clinical practice.

METHOD

The T-tube (Fig. 1,*E*), which is firmly inclosed in the common bile duct, is connected to a manometer, *D*, which consists of two perpendicular glass tubes connected at the base. Into one glass tube there is a continuous flow at the rate of 3 cubic centimeters per minute of sterile saline from a reservoir, *C*. A light aluminum needle floats on the surface of the saline of the other tube. By this means a record is made on the small portable kymograph, *A*, which makes a complete revolution in 1 hour. Since the depth of the common bile duct from the surface of the abdomen can be measured by the length of the tube, the height of the fluid, *J*, in the manometer can be accurately recorded. There is then a continuous flow of saline through the common duct sphincter, *F*, and the resistance to flow can be measured by the manometer. To make sure that there is no positive pressure in the duodenum, *G*, a duodenal tube, *H*, is passed by mouth and the open end is allowed to hang over the side of the bed. As a result of the syphonage a negative pressure, *K*, is created.

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It was found that the resistance to the flow of fluid through the sphincter did not change either on removal of the duodenal tube, or on the injection of 20 cubic centimeters of fluid through it. The duodenal tube, however, was used in all recordings, since in addition to creating a negative duodenal pressure, different materials could be injected into the duodenum for experimental purposes.

In addition to the kymographic records a number of readings were made in different cases of the resistance of the sphincter to a column of fluid. A tube about 3 millimeters in diameter was attached to the T-tube, filled with sterile saline, and raised gradually until the resistance broke and the column of water gave way. This "breaking point" measured the static resistance of the sphincter. By making frequent consecutive readings, alterations in the resistance of the sphincter could be recorded. This method, of course, was not as satisfactory as having a continuous kymographic record which measured the actual dynamic resistance of the sphincter to a continual flow of fluid.

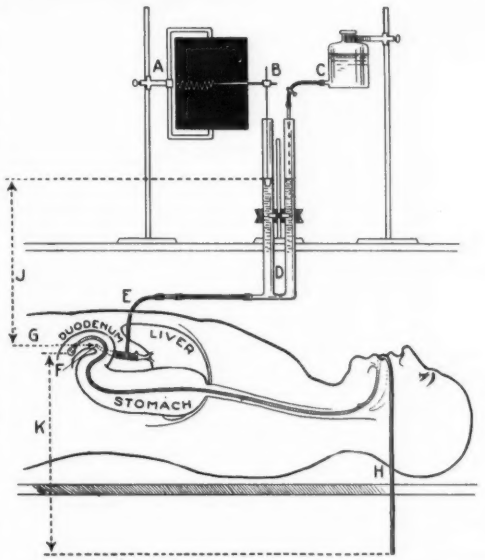


Fig. 1. Kymographic recording of resistance of the common duct sphincter to the flow of fluid. *A*, Kymograph; *B*, recording needle floating on surface of saline in manometer; *C*, reservoir of sterile saline from which fluid flows at rate of 3 cubic centimeters per minute; *D*, double manometer; *E*, T-tube in choledochus; *F*, sphincter of Oddi; *G*, duodenum; *H*, duodenal tube hanging over side of bed; *J*, height of fluid from sphincter of Oddi to manometric level; *K*, height from end of duodenal tube to duodenum, resulting in effective negative pressure in duodenum as the result of siphonage.

EXPERIMENTAL

A number of observations were made early in this work on the resistance of the common duct sphincter by means of a simple manometer tube. This method measured the point at which a column of fluid broke, i.e., the height required to force the sphincter open. It was noted that often the first reading was much higher than the subsequent ones. Apparently a sphincter requires more force to cause an initial relaxation. Once it has been opened the resistance to the column of fluid becomes lower and then remains constant. It was found that this resistance remained constant over a long period of time. By making frequent readings the effect of materials injected into the duodenum could be measured.

CASE 1. (Hosp. No. 386925.) A woman, 49 years of age, was admitted to the hospital on June 1, 1935, with a history of attacks of epigastric pain, chills, fever, vomiting, icterus, and pruritus. Three months previously a cholecystectomy and a choledochostomy for common duct calculus had been performed. Operation was performed June 8, 1935. The common duct was found dilated, thickened, and containing infected bile full of flakes and inspissated material. Culture of this material revealed the presence of Bacillus coli. There was, however, no stricture or obstruction of the papilla of Vater. A T-tube was inserted and drainage was carried out for 3½ months. During the last 2 months before the tube was removed, it was tied off during 16 hours of the day without effect and patient remained symptom-free. During that period the resistance of the common duct sphincter was measured several times. The results are recorded in Table I. It can be seen that on June 16, 1935, 8 days after operation, the resistance was 125 millimeters water. After the oral administration of 50 cubic centimeters of 50 per cent magnesium sulphate the resistance was found to be 85 millimeters at the end of 15 minutes. The administration of a clear chicken soup apparently caused a slight fall in resistance of the sphincter. At the end of 2 hours, the resistance was back to 125 millimeters (Table I). On July 11, 1935, 1 month after operation, the resistance averaged 116 millimeters. Apparently the tone of the sphincter had increased. Two months later, on September 19, 1935, as a result of tying off the tube daily for 16 hours, there was a partial loss of sphincteric tone.

TABLE I.—RESISTANCE OF THE SPHINCTER OF ODDI MEASURED BY THE "BREAK" IN A COLUMN OF FLUID—CASE I

Day after operation	Time	Resistance mm. H_2O	Remarks
8	12:10	125	Magnesium sulphate 20 c.cm. 50 per cent
	...	110	
	...	90	
	12:25	85	
	...	90	
	1:10	95	
	1:12	102	Soup administered
	1:14	90	
	1:16	93	
	2:00	125	
33	...	116	
93	12:10	110	Tube had been closed for 16 hours daily for 2 months
	1:30	110	Resistance remained constant
	1:57	110	20 c.cm. 50 per cent magnesium sulphate
	2:00	125	Epigastric distention
	2:04	...	Bile flow through duodenal tube
	2:08	105	No distress; continuous flow of bile through duodenal tube
	2:12	95	
	2:15	103	
	2:20	...	20 c.cm. 0.9 per cent HC
	2:21	135	
	2:25	140	
	2:30	110	
	2:35	105	20 c.cm. 0.9 per cent HCl
	2:36	136	
	2:38	108	
	2:40	103	
	2:41	...	20 c.cm. 0.5 per cent NaOH
	2:42	105	
	2:50	105	Discontinued

The resistance of the sphincter now measured 110 millimeters. Injection of 50 per cent magnesium sulphate into the duodenum caused the resistance to fall to 95 millimeters, although immediately after the injection there was an increased resistance. This may have been due to the fact that the magnesium sulphate solution was cold (5). Injection of hydrochloric acid caused a typical spasm, the resistance rising to 140 millimeters. The second application of hydrochloric acid caused the same effect. The injection of sodium hydroxide caused no change in the resistance of the sphincter (Table I). On September 26, 1935, the first kymographic record was made on this patient. The resistance remained steady at 140 millimeters water (Fig. 2). On the instillation of 0.9 per cent hydrochloric acid into the duodenum, the resistance rose to 190 millimeters and stayed up about 10 minutes. When the base line was reached again, 50 cubic centimeters of 50 per cent magnesium sulphate was injected into the duodenum. The resistance gradually fell to 125 millimeters. Due to the presence of the duodenal tube, the patient suddenly became nauseated and vomited. As can be seen, the resistance of the sphincter rose rapidly to 170 millimeters and then gradually subsided to 140 millimeters.

Six weeks after removal of the T-tube the original symptoms recurred, indicating that infection of the biliary tract was again present. At reoperation on December 4, 1935, the common duct was again found inflamed and the bile infected. A piece of liver removed at this time showed widespread chronic pericholangitis. An attempt was made to destroy the sphincter of Oddi but this was unsuccessful. The resistance of the common duct sphincter was measured several times. On December 6, 1935, 2 days after operation, it averaged 150 millimeters water. On January 2, 1936, 1 month after operation the resistance was unchanged, varying between 140 and 160 millimeters water (Fig. 3). During the recording of the resistance, the patient was given soup, two eggs, and ice cream. The effect of this fat meal was negligible over a period of over half an hour. The resistance fell for a time about 20 millimeters water only (Fig. 3). The effect of a fat meal seemed to be less than the fall produced by magnesium sulphate instillation. On February 27, 1936, the resistance of the sphincter averaged 150 millimeters water (Fig. 4). During all this period the fistula continued to drain bile, very little entering the duodenum. On March 3, 1936, 3 months after operation, the resistance had risen somewhat, averaging 165 millimeters water (Fig. 4). The instillation of acid caused sphincteric spasm, raising the resistance to 195 millimeters water. This indicated that the sphincter was still functioning.

TABLE II.—RESISTANCE OF THE SPHINCTER OF ODDI MEASURED BY THE "BREAK" IN A COLUMN OF FLUID

Case No.	Day after operation	Resistance mm. H_2O	Remarks
2	6	230	Initial resistance. Epigastric distress until resistance overcome
		170–190	Ensuing constant resistance
	12	260	Initial resistance
		220	Ensuing constant resistance
3	3	180	Constant resistance
	6	220	Initial resistance for 2 minutes
		160	Ensuing constant resistance
4	3	225	Initial resistance
		185	Ensuing constant resistance
	6	225	Constant resistance
5	8	55	Constant low resistance
6	1 hour	230	Constant resistance
	2 days	140	Constant resistance

CASE 2. (Hosp. No. 381680). F. S., a housewife, aged 61 years, had suffered from attacks of right upper quadrant pain for 20 years. With her last attack, 24 days before operation, she developed jaundice. On admission the icteric index was 160, and the bilirubinemia 14 milligrams per cent. Under observation the icteric index fell to 30. At operation a thickened gall bladder was found full of stones. The choledochus was dilated and contained pigment stones and precipitated material. A choledochostomy was performed. Urobilin was not found in the stool until the eighth day. On the sixth day, the resistance of the sphincter was measured with a manometer. The column of fluid had to be raised to 230 millimeters before the sphincter gave way and the column "broke" (Table II). During that period

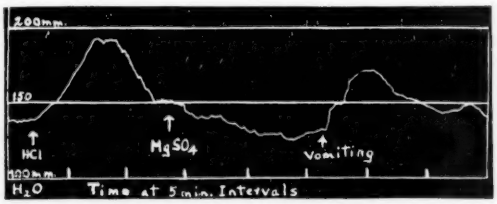


Fig. 2. Case 1. Kymographic record of effect of duodenal instillation of dilute hydrochloric acid and of magnesium sulphate. The spasm associated with nausea and vomiting is also recorded.

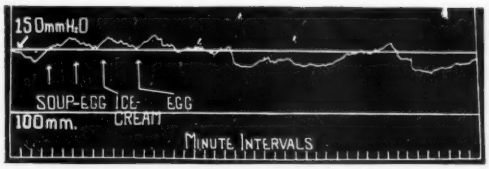


Fig. 3. Case 1. Patient was given meal of soup, two eggs, and ice cream. Note that no significant change in resistance occurred for a period of 40 minutes following this fat meal.

the patient complained of epigastric distress, which disappeared as soon as fluid began to flow. Following the first reading subsequent readings all showed the resistance to measure 170-190 millimeters water consistently. On lipiodol injection study 3 days later (Fig. 5), it was seen that sufficient pressure had to be used to outline all the larger hepatic ducts before a little lipiodol could be forced into the duodenum. The examination of the roentgen-ray plate revealed that the ducts were somewhat dilated. The intramural portion of the choledochus was not outlined, probably due to pressure of the duodenal wall. The spasm of the sphincter is evidenced by the fact that, although the ampulla of Vater was shown to be filled, only a few drops of lipiodol could be seen in the duodenum. Twenty-four hours later, roentgen-ray examination revealed no lipiodol in the intestinal tract, but some still remained in the hepatic ducts. In other words the persistent sphincteric spasm had prevented the lipiodol from entering the intestine, and as a result, most of the lipiodol had been washed out through the fistula. Lipiodol examination therefore supported the manometric readings.

On the twelfth day, the common duct sphincter resistance was again measured. The initial resistance was 260 millimeters water (Table II), but when this was overcome the readings steadied at 220 millimeters water. The next day, the choledochostomy T-tube was tied. The patient was atropinized, the magnesium sulphate was given by mouth. Following this, the stools which had previously been acholic contained bile. A lipiodol examination on the fourteenth day still indicated marked spasm. Although urobilin was present in the stools, only a few globules of lipiodol could be forced into the duodenum. Sufficient pressure was used to outline the hepatic ducts in some detail (Figs 6 and 7). The results indicate clearly that the sphincter of Oddi was definitely spastic, and had prevented the passage of bile into the intestine for 2 weeks.

The tube was removed on the twentieth day. After draining for some weeks the fistula closed and the patient has been well since.

Case 3. (Hosp. No. 382059). H. S., a white male, aged 57 years, gave a history of 4 attacks of epigastric pain, radiating to the right costal margin, and to both scapulas, during the past year. The last attack occurred 20 days before operation. Seven days later, jaundice was noted. On admission the liver was found to be large; bile was present in the duodenal drainage and in the stools. The icteric index was 90. At operation the gall bladder was found thickened and distended but contained no stones. The choledochus was slightly dilated and contained one large stone. A probe passed easily into the duodenum. Choledochostomy was performed.

Three days after operation the sphincter was found to resist a column of fluid 180 millimeters high. On the sixth day the measurement was repeated. The initial resistance was 220 millimeters water, but after maintaining this resistance for 2 minutes, the sphincter gave way and the resistance was then maintained at 160 millimeters water. Lipiodol examination 5 days later (Fig. 8) revealed a dilated common duct. The hepatic ducts were outlined but not dilated. Apparently then some pressure had to be used to overcome the sphincter resistance. Lipiodol was seen to enter the duodenum through a long narrow channel. The results indicate that the sphincter was spastic for a short time after operation. The tube was clamped 14 days after operation and removed 3 days later. The fistula closed rapidly, and the patient has been well since.

Case 4. (Hosp. No. 382140). C. F., a housewife, aged 60 years, had suffered from attacks of gall bladder pain for 5 years. With the last attack, 12 days before operation, jaundice was noted. The

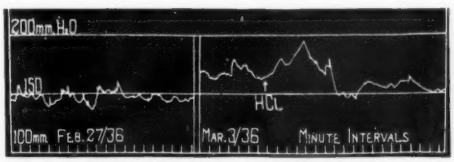


Fig. 4. Case 1. Kymographic record of sphincter resistance on February 27, 1936, 54 days after operation, shows a typical tracing averaging 155 millimeters water. On March 3, 1936, the resistance was found to average 165 millimeters. Duodenal instillation of hydrochloric acid caused resistance to rise to 190 millimeters. The ensuing relaxation allowed the resistance to fall to 150 millimeters.

Fig. 5.

Fig. 5. Case 2. Lipiodol injection 9 days after operation shows that sufficient pressure had to be used to outline the hepatic ducts rather fully before a few drops of lipiodol entered the duodenum. Note especially that the ampulla of Vater is distended with lipiodol indicating sphincter spasm (arrow).

Fig. 6.

Fig. 7.

Figs. 6 and 7. Case 2. Lipiodol injection 14 days after operation shows sphincter spasm still persistent. Anteroposterior view (Fig. 6) shows beginning visualization of intrahepatic ducts without lipiodol entering the duodenum. On increasing the pressure, the hepatic ducts are further outlined (Fig. 7, lateral view) and lipiodol is seen entering the duodenum (arrow).

icteric index was 50, and the bilirubinemia 2.0 milligrams per cent. At operation the gall bladder was found full of stones and acutely inflamed. The common duct was thickened and enlarged to twice its normal diameter; it was filled with a sandlike precipitate, but contained no stones. Cholecystectomy and choledochostomy were performed. Urobilin was not present in the stools until the nineteenth day. In addition pancreatic enzymes were detected in the fistula drainage on several occasions. These facts pointed to spasm of the common duct sphincter. This was supported by the measurement of the resistance on two occasions. On the third day, the initial resistance was 225 millimeters water. On the tenth day, injection of lipiodol outlined the hepatic ducts extensively (Figs. 8 and 10), and only a slight amount of lipiodol entered the duodenum in droplets. The following day no lipiodol was seen in the duodenum, but some still remained in the choledochus, while the remainder was seen in the dressings. The lipiodol examination, the absence of urobilin from the stools, and the presence of pancreatic enzymes in the fistula bile, all support the findings of a spastic sphincter.

Fig. 8. Case 3. Lipiodol study 11 days after operation shows the hepatic ducts outlined in some detail. The choledochus is dilated and lipiodol is seen entering the duodenum through a long fine channel (arrow).

Case 5. (Hosp. No. 380515). G. K., a housewife, 51 years of age, was well for 8 years following a cholecystectomy. She was admitted to this hospital with a history of three attacks of severe epigastric pain during the previous 3 months. While in the hospital another attack occurred, this time associated with jaundice. The icteric index rose to 45, while the blood amylase was found to be 42 (Elman) units. At operation, the choledochus was found to be 1 inch in diameter and contained two small pigment stones. The pancreas was hard and enlarged, producing partial obstruction. A punch biopsy of the pancreas showed acute interstitial pancreatitis and the presence of bile pigment in the finer radicles of the pancreatic duct (Fig. 12). Choledochostomy was performed. The patient drained small amounts of bile. The tube was removed accidentally on the ninth day. The fistula closed rapidly and the patient has been well since.

The resistance of the common duct sphincter was measured on the eighth day, and found to be very low (Table II), averaging 55 millimeters water. The presence of bile in the pancreatic duct indicated that obstruction had occurred at the ampulla of Vater.

Fig. 9.

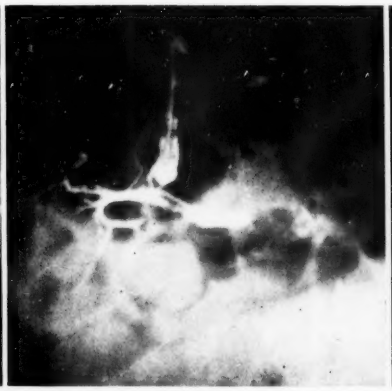


Fig. 10.

Fig. 11.

Figs. 9 and 10. Case 4. Anteroposterior (Fig. 9) and lateral (Fig. 10) views of lipiodol study, show that hepatic ducts were outlined in some detail before lipiodol could be forced into the duodenum.

Fig. 11. Case 4. Roentgenogram taken the day after injection of lipiodol into the biliary tract (Cases 9 and 10) reveals the presence of some lipiodol in the choledochus and in the dressings. None has passed into the duodenum.

The obstruction was due undoubtedly to a stone which was removed at operation. The clinical course as evidenced by the fact that there was only slight drainage through the fistula without evidence of jaundice, supports the manometric findings of low sphincter resistance.

Case 6. (Hosp. No. 381208). B. G., a housewife, aged 66 years, had suffered from diabetes for 15 years. Eight weeks before operation she began to develop attacks of biliary colic, associated with slight jaundice. Two days before operation jaundice became marked and fever was present. On admission the icteric index was 30, with bilirubinemia of 1.5 milligrams per cent. At operation the gall bladder was found to be shrunken and contained no stones. The choledochus was dilated and contained a single large stone. Choledochostomy was performed. The tube was dislodged on the fourth day, but she continued to drain bile for 7 weeks before closure of the fistula.

The resistance of the sphincter 1 hour after operation was found to be 230 millimeters water (Table II). This high resistance may have been due either to the operative trauma or to the pre-operative administration of morphine which, as will be shown later, causes increased spasm for a long period of time.

Two days after operation, the measurement of the sphincter resistance was repeated and found to be 140 millimeters water, thus lying within normal limits. A lipiodol study immediately afterward (Figs. 13 and 14) showed a pocket near the region of the gall bladder, a markedly dilated choledochus with few of the large hepatic radicles outlined and lipiodol entering the duodenum. This study confirmed the finding of a low sphincteric resistance by actual measurement.

Case 7. (Hosp. No. 391032). J. J., a salesman, 44 years of age, first developed severe attacks of right subcostal pain 7 months previous to admission to this hospital. The attack persisted for 3 weeks. At the same time he was found to have diabetes. He had four similar attacks since then, the last one occurring 4 days before admission. The last two attacks were accompanied by fever up to 101 degrees F., and icterus. On admission the icteric index was 9, and bilirubinemia 1.2 milligrams per cent. Urobilin was present in the stool. Before operation the icteric index had fallen to 5 and the bilirubinemia to 0.4 milligrams per cent. At operation the gall bladder was found to be shrunken and thickened. An old perforation into the liver bed was present in which stones were found. The choledochus was

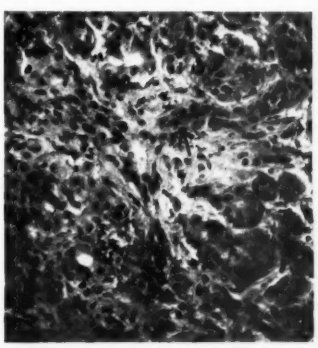
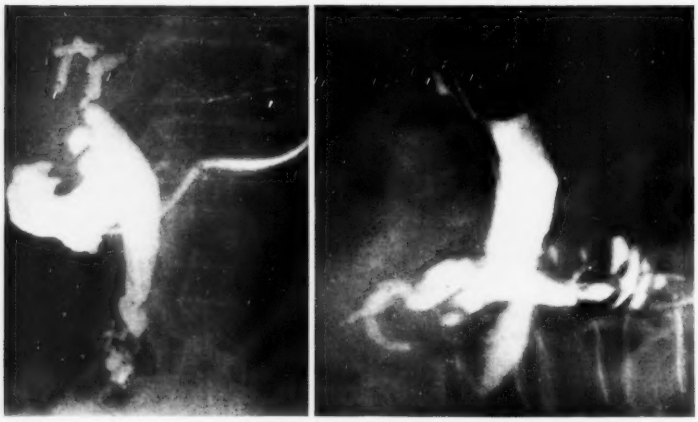


Fig. 12. Case 5. Punch biopsy of pancreas removed at operation reveals the presence of acute interstitial pancreatitis. Bile pigment can be seen in many of the fine pancreatic ducts (arrow).



Figs. 13, left, and 14. Case 6. Anteroposterior and lateral views of a lipiodol study 2 days after operation. Lipiodol entered the duodenum easily without visualizing the finer hepatic ducts, confirming the manometric finding of a low sphincter resistance.

markedly thickened and dilated to 1 inch in diameter. A cholesterol stone was found in the retroduodenal portion. Cholecystectomy and choledochostomy were performed. A biopsy of the liver revealed a conspicuous number of bile thrombi and an increased number of leucocytes in the periportal fields. The choledochostomy T-tube was clamped on the twenty-second day. After 6 days, the tube was opened, a sample of bile was obtained, and the tube was removed. Convalescence was uneventful, and the patient has been well since.

The tube was solidly healed in place by the tenth day, and since the patient was co-operative, a number of experiments were carried out on the effect of various drugs on the resistance of the common duct sphincter.

EXPERIMENTS—CASE 7

1. *The influence of atropine on the spasm produced by the local application of hydrochloric acid.* The resistance of the sphincter was registered on the kymograph at 165 millimeters (Fig. 15). Through a duodenal tube, 20 cubic centimeters of 0.9 per cent hydrochloric acid were injected. As in Case 1 (Fig. 2), spasm was produced which lasted about 10 minutes. Here the resistance rose to 255 millimeters water. After return of the resistance to the base line, atropine sulphate (gr. 1/75) was given hypodermically. When the pulse rate was definitely increased, about 8 minutes after the injection, 20 cubic centimeters of hydrochloric acid was again introduced into the duodenum. As can be clearly seen on the kymographic record, practically no spastic reflex at all was present. The resistance went up about 10 millimeters water only. In this case sphincteric spasm produced by acid irritation could be completely prevented by atropine. A slight drop of 15 millimeters in the resistance can be noted at the end of the record, probably due to the atropine.

2. *The influence of atropine on an irritable sphincter.* On one occasion the kymographic record revealed the common duct sphincter to be very irritable (Fig. 16). The average resistance tended to be about 165 millimeters water, but the sphincter was constantly going into spasm. The cause of this was unknown. The hypodermic injection of atropine sulphate, first grain 1/75, and then 20 minutes later grain 1/150, had very little effect. It can be noted, however, that 18 minutes after the first injection, the irritability of the sphincter was diminished. The effect of the two injections lasted about 20 minutes. This result was synchronous with the increased pulse rate resulting from the atropine. In this case atropine was apparently able to diminish the irritability of the common duct sphincter but did not lower its resistance which lay in the normal range.

3. *The influence of morphine on the common duct sphincter.* Although morphine is widely used to control the pain of colic, it has long been known to cause smooth muscle spasm. The effect on the common duct sphincter was recorded on the kymograph (Fig. 17). The effect of the local application of hydrochloric acid was first tried to test the functional ability of the sphincter. As can be seen, the resistance rose from about 160 to 260 millimeters water. This increase lasted about 9 minutes. When the resistance had come down, morphine sulphate, grain ¼, was given subcutaneously into the arm. Spasm was evident in 2 minutes and the resistance rose to 340 millimeters water. During the second hour the resistance rose to 370 millimeters; during the third hour it remained at 200 millimeters. In other words, in this case morphine produced almost instantaneous spasm which was twice as powerful as that which was produced by hydrochloric acid and the effect of which lasted to some degree for a period of more than 4 hours.

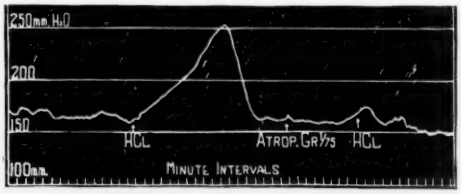


Fig. 15. Case 7. Kymographic record shows that the instillation of dilute hydrochloric acid into the duodenum causes spasm that lasts about 10 minutes. Under the influence of atropine hypodermically this reflex spasm is abolished.

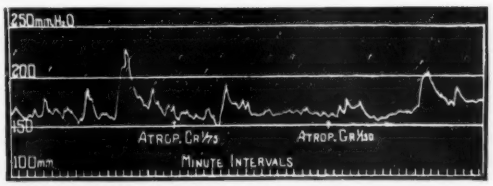


Fig. 16. Case 7. The kymographic record of an irritable sphincter showing the rapid changes in resistance. The hypodermic injection of atropine caused very little change in the average resistance but apparently abolished the irritability of the sphincter for about 20 minutes.

A lipiodol study was undertaken to study the effect of morphine on sphincteric spasm. The patient was given morphine sulphate (grain ¼) subcutaneously and 5 minutes later, lipiodol was injected into the biliary tract through the T-tube. As can be seen (Fig. 18) sufficient force was exerted to distend some of the finer hepatic radicles, and yet no lipiodol entered the duodenum. The force of injection was gradually increased, until globules of lipiodol could be seen shooting like bullets through a narrow spastic sphincter into the duodenum. At this point, a plate showed that sufficient force had been applied to fill and visualize the very finest bile duct radicles as well as the pancreatic duct (Fig. 19). This demonstrates clearly that sphincteric spasm can convert the choledochus and duct of Wirsung into a common channel.

The next day when the lipiodol had disappeared from the biliary tract and intestine, a fresh supply was injected. It can be seen (Fig. 20) that the hepatic ducts are much less outlined than in Figure 18, and yet the duodenum contains lipiodol. It is quite evident that the administration of morphine had caused a marked spasm of the sphincter.

4. *The influence of atropine on the spasm produced by morphine.* Morphine sulphate (gr. ¼) and atropine sulphate (gr. 1/75) were given simultaneously by hypodermic injection (Fig. 20). Within 2 minutes the resistance of the common duct sphincter rose from a base line of 160 to 320 millimeters water. Even during the third hour the resistance was still 230 millimeters water. It is evident that atropine does not modify the spastic action of morphine. This result can be expected from the pharmacological action of these drugs, since atropine acts on the parasympathetic nerve endings causing paralysis while morphine acts directly on smooth muscle.

The action of the hypertonic sphincter can be visualized by observing the kymographic record closely. As fluid flows in, the pressure rises to a peak. The sphincter suddenly gives way and the resistance drops 20 millimeters. The pressure then gradually rises again, and the whole process is repeated. The kymographic tracing records the continual opening and closing of the sphincter and this measures the dynamic resistance of the sphincter to the flow of fluid.

5. *Effect of papaverine on the common duct sphincter.* Papaverine is supposed to act directly on smooth muscle causing relaxation without paralysis. Its action on the sphincter in a dosage of 64 milligrams was found to be negligible (Fig. 21). The drug was given subcutaneously and the amount was one-third higher than the dosage ordinarily recommended.

6. *The action of pantopon and the influence of papaverine on the smooth muscle spasm of morphine.* Since pantopon is supposed to contain papaverine and so produce less spasm than an equivalent dose of morphine alone, its effect on the sphincter was investigated. After giving 20 milligrams (gr. ⅓) hypodermically, the resistance immediately rose from 140 to 350 millimeters (Fig. 23). Its action is therefore exactly similar to that of morphine.

One-half hour after the administration of pantopon, 40 milligrams (gr. ⅔) of papaverine was given hypodermically. A slight fall followed this and a large definite fall of 80 millimeters 20 minutes later. This precipitous fall in the resistance was apparently due to the papaverine since the resistance rose again to 300 millimeters water. The action of papaverine seemed to be slow and evanescent, even in the presence of a spastic smooth muscle.

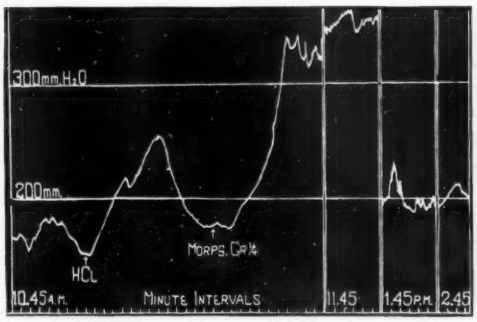


Fig. 17. Case 7. Kymographic record of the prolonged sphincter spasm produced by morphine. The spastic effect of the local application of hydrochloric acid is first shown. As can be seen, the spasm produced by the morphine is twice as severe and the effect is still present during the fourth hour.

Fig. 18.

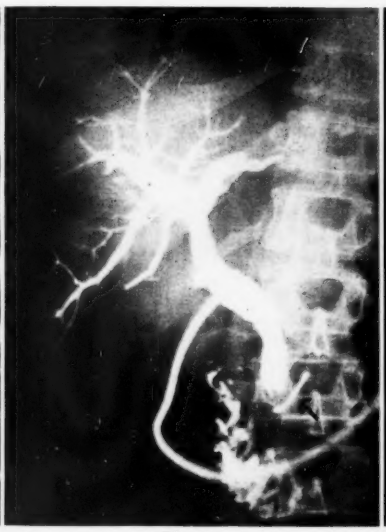


Fig. 19.

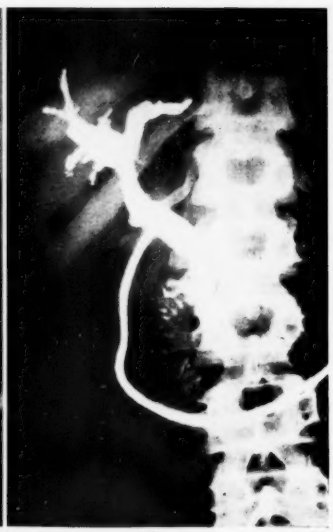


Fig. 20.

Figs. 18 and 19. Case 7. Lipiodol was injected through the T-tube 5 minutes after the hypodermic administration of morphine (gr. ¼). The hepatic ducts are outlined in some detail while no lipiodol is present in the duodenum (Fig. 18). On increasing the pressure of the injection, lipiodol is forced into the duodenum, but the pressure is so great that the fine hepatic ducts are outlined (Fig. 19). In addition, spasm of the sphincter permitted lipiodol to be forced up the pancreatic duct (arrow).

Fig. 20. Case 7. Roentgen-ray plate taken after injection of lipiodol on the day following the plates seen in Figures 18 and 19. In the absence of sphincter spasm produced by morphine, lipiodol is seen to enter the duodenum; the hepatic ducts are visualized only slightly.

7. *The action of adrenalin and of food on the sphincter.* With the resistance of the sphincter averaging 140 millimeters, 1 cubic centimeter adrenalin (1:1000) was administered subcutaneously (Fig. 24). The pulse rate increased and the patient complained of precordial discomfort, but the resistance rose at most only 20 millimeters, water. When the effect of the adrenalin had worn off, the patient was given a full meal and the effect on the sphincteric resistance was recorded. As can be seen the administration of a full meal had no active effect on the sphincteric resistance. The same thing was noted in a previous case (Fig. 3).

Certain mechanical factors involving the apparatus must be considered in interpreting the kymographic tracings. Fluid flows in at the rate of 3 cubic centimeters per minute. When spasm of the sphincter takes place suddenly, the actual increase in resistance is not measured immediately. The capacity of the two vertical tubes is fairly large, and it was found that at the regular rate of inflow of fluid, it took 3 minutes for the needle to rise 100 millimeters. The result is that if sphincteric spasm suddenly increases the resistance 200 millimeters, its maximum effect will not be recorded for 6 minutes. Thus in Figure 17 the resistance began to rise 2 minutes after the injection of morphine as a result of its absorption. Spasm was probably complete in 2 minutes, but it took approximately 6 more minutes for the tracing to show the maximum rise. Small changes in resistance are, of course, recorded almost instantaneously since inflow of fluid would cause rapid change in the level.

In considering the persistence of biliary drainage through a choledochous fistula tube, certain relative mechanical factors must be considered. The common bile duct usually lies about 120 millimeters below the surface of the body. In flowing out through the fistula the pressure of bile flow must overcome the resistance of this column of fluid, which actually acts as a manometric tube. Even if the resistance of the common duct sphincter is normal, i.e., about 150 millimeters water, it

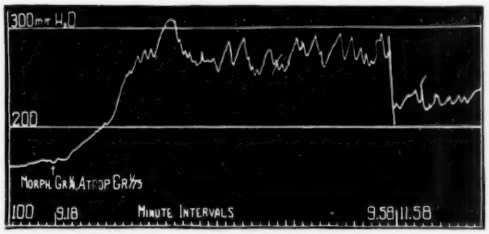


Fig. 21. Case 7. Kymographic record following the simultaneous administration of morphine and atropine hypodermically. It can be easily seen that the prolonged sphincter spasm resulting from morphine is not affected by atropine.

will still be greater than the fistula resistance. Bile will then always continue to flow through the fistula tube as long as it remains open. As soon as the tube is removed, the tissue turgor and the healing process rapidly increase the fistula resistance until it lies above the sphincteric resistance. The secretory pressure of the liver, which lies between 200 to 300 millimeters water (8, 11), then comes into action and forces the sphincter open. The resistance of the sphincter due to the continuous pressure of the liver bile apparently falls to rather low levels (7). Thus, in both Cases 1 and 7, after closure of the tube, the resistance of sphincter fell definitely. The resistance may increase later due to nervous factors or to infection as in Case 1.

In cases in which the fistulous tract is fairly wide in diameter after removal of the tube and in which the distance of the choledochus to the abdominal surface is short, the fistula may persist for a long time, even if the sphincteric resistance is normal. Thus in Case 6, although the sphincteric resistance was only 140 millimeters the biliary fistula persisted for 7 weeks. The distance of the choledochus to the abdominal wall was short and, in addition, the fistulous tract was very wide.

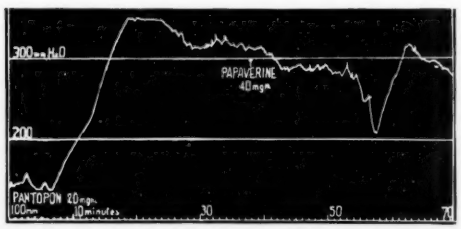


Fig. 23. Case 7. Hypodermic injection of pantopon causes severe prolonged sphincter spasm, identical to that produced by morphine. Twenty minutes after the injection of papaverine there is an abrupt fall in the resistance lasting only about 5 minutes.

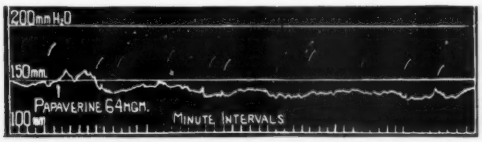


Fig. 22. Case 7. The kymographic record shows that papaverine in therapeutic dose has no relaxing effect on the resistance of the normal sphincter.

It is impossible, of course, to determine the resistance of the normal sphincter in the human, since only cases with pathological conditions are available. In Case 1, infection was quite marked at first. In addition, the gall bladder was removed. The result was that the safety valve action of the gall bladder was absent and the secretory pressure of the liver could act directly on the sphincter for varying periods of time. Following drainage for a period of over 3 months after the first operation all symptoms of infection disappeared. The resistance was then found to be 140 millimeters water (Fig. 2). In Case 7, after cholecystectomy and removal of a choledochus stone, the resistance of the sphincter was found to be consistently 160 millimeters (Figs. 15, 16, 17, 21, 22). There was no evidence of infection, nor any symptoms. The fistula was draining bile and so acting as a safety valve. After closure of the tube the resistance fell to 140 millimeters (Figs. 23 and 24). Again there were no symptoms and no sign of infection. In these 2 cases, therefore, when conditions in the choledochus were apparently fairly normal, the resistance of the sphincter averaged about 150 millimeters water.

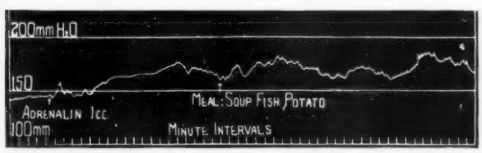


Fig. 24. Case 7. Adrenalin is shown to have only a slight effect on the sphincteric resistance. A complete meal was then given. As can be seen the effect on the resistance of the sphincter was negligible, during the next half hour.

The effect of food on the sphincteric resistance is very interesting. The gall bladder is known to contract and empty following the intake of a meal containing fat or protein. There is supposed to be a reciprocal relationship between the gall bladder and the sphincter, the sphincter relaxing as the gall bladder contracts. This may be true in the intact biliary tract, but the evidence as shown in Figures 3 and 23, cases in which a cholecystectomy had been performed, indicates that neither a fatty nor a regular meal has any influence on the sphincteric tone. In addition, as in Cases 2, 3, and 4 (Table II), the measurements indicate that the sphincter tends to have a higher initial resistance than the resistance present during the flow of bile. In the normal biliary tract the intraductal pressure tends to remain at about 100 millimeters' water. Therefore the only force to overcome the initial resistance of the sphincter would be the motor activity of the gall bladder, which can develop a force of 300 millimeters' water.

The well known action of magnesium sulphate in causing relaxation of the sphincter is confirmed in the two experiments in Table I, and in the kymographic record in Figure 2. There are clinical claims that regular duodenal lavage with magnesium sulphate often relieves patients suffering from gall-bladder disease or the post-cholecystectomy syndrome. This opinion seems to be supported by our observations in that magnesium sulphate is much more efficient than ordinary meals or even fat meals in causing relaxation of the sphincter.

Oddi first observed that spasm of the functioning sphincter will be produced by the local application of hydrochloric acid in animals (14). This observation has been frequently confirmed (1). Such an effect has now been shown to occur in the human. Table I, and Figures 2, 4, 15, 17, demonstrate this conclusively. It is well known that a certain number of sufferers from gall-bladder disease have hyperacidity. They are the most intractible cases to treat since they appear to have frequent recurrent spasms of the sphincter of Oddi. It is known that the most effective treatment in these cases is the administration of alkalies and atropine. The experiment demonstrated in Figure 15, of the abolition by atropine of the sphincteric reflex spasm to the action of hydrochloric acid, gives a conclusive experimental basis for such a therapy.

The action of the various drugs tested on the sphincter is of considerable interest. Neither adrenalin nor papaverine in the ordinary dose were found to have any marked effect. The action of morphine in causing severe spasm is of great clinical importance in the treatment of biliary colic. It is evident that when the gall bladder is not functioning or is absent, the injection of morphine will cause severe back pressure on the liver which may last for 4 hours. The consequent damage to that organ due to recurrent functional obstruction may eventually be very great. For many years the French school of medicine has recommended the use of atropine in biliary colic. It is the logical drug to use. Unfortunately, its action is transitory, and it will not relieve a certain number of patients, those for instance with hydrops following acute cystic duct obstruction. Although morphine undoubtedly increases the damage to the hepatobiliary system, it abolishes pain by its central action and so produces relief. Pantopon is supposed to produce less spasm than morphine, but our observations fail to confirm this. A satisfactory drug for the treatment of biliary colic is still to be found.

CONCLUSIONS

1. An apparatus is described for the kymographic recording of the resistance of the human common duct sphincter to the flow of bile. The procedure can be carried out only in patients with a T-tube in the choledochus.
2. Spasm of the common duct sphincter has been shown to exist in human cases.
3. Ingestion of food does not cause sphincteric relaxation in the absence of the gall bladder.
4. Duodenal lavage with magnesium sulphate causes relaxation of the sphincter.
5. Instillation of dilute hydrochloric acid into the duodenum causes temporary sphincteric spasm. This reflex is prevented by atropinization.

6. Morphine produces severe sphincteric spasm which lasts over 3 hours. This spasm is not influenced by atropine.

7. Papaverine may produce a temporary relaxation of a spastic sphincter, but ordinarily has slight effect.

8. The effect of adrenalin on the sphincteric resistance under the conditions reported here is negligible.

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NOTE.—Since this article was submitted for publication the following articles have appeared in the *Journal of the American Medical Association*.

KIPP, H. A.. Observations on the variations in bile pressure in the human biliary tract. J. Am. M. Ass., 1936, 106: 2223.

KOSTER, HARRY, SHAPIRO, ARTHUR. Letter, J. Am. M. Ass., 1936, 107: 372.

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HYDRONEPHROSIS IN INFANCY AND CHILDHOOD

Clinical Data and a Report of 101 Cases

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As more and more attention is directed toward the study of the urinary tract in infants and children, our knowledge of this particular field in urology will be greatly broadened and, as a result, much information will be obtained regarding the nature, incidence, and extent of the various urological lesions of infancy and childhood. With such information available there will naturally result a better and more widespread understanding of the subject which, undoubtedly, will result in benefit to the patient in regard to early diagnosis and treatment. It is needless to emphasize at this time that early diagnosis and early treatment are imperative in renal surgery if irreparable damage to the kidney is to be prevented (Fig. 1).

Recent studies verify the statements made by various authors, in this as well as in other countries, that renal tuberculosis in children is rare (1, 3). Furthermore, the general impression that urinary stones in children are relatively uncommon in this country likewise seems to be confirmed by the experience of urologists and pediatricians (4). As time goes on, more and more information will be obtained concerning these lesions as well as other lesions of the urinary tract in children, so that more will be known and understood in regard to early symptoms, thus making possible early diagnosis and treatment.

Pyelonephritis (acute or chronic) is probably the most common condition that occurs in the urinary tract in children. While it is true that a large number of these cases clear up either spontaneously or with medical management, it is important to bear in mind that the clinical picture of pyelonephritis often masks other serious lesions of the kidney, as stone, tuberculosis, or hydronephrosis.

From the Presbyterian Hospital and the Children's Memorial Hospital, Chicago, Illinois.
Read by title at the American Association of Genito-Urinary Surgeons, Stockbridge, Massachusetts, May 25–27, 1936.

In my own experience the cases of hydronephrosis that have come under observation far outnumber the cases of stone, tumor, or tuberculosis. I fully realize that this is my experience and that it may not tally with the experience of others.

This paper is based upon a study of 101 cases from the Presbyterian Hospital, Children's Memorial Hospital, and from the records of private patients. Cases of hydronephrosis associated with tuberculosis are not included.

AGE

The youngest patient in this series was a boy 3½ weeks old who had a double kidney and a double ureter; he had a marked hydronephrosis of the upper half of the kidney as well as a marked dilatation of the ureter. There were 15 cases under 1 year of age and 25 cases under 2 years of age, an incidence of 24.7 per cent before the age of 2 years.

Attention should be called to the large number of cases that occurred before the second year. No patients were included over 13 years of age; there were 14 cases between the ages of 11 and 13 years, 5 of whom were 13.

TABLE I.—AGE

	Cases
Under 6 months	9
6 mos. to 1 yr	6
1 yr. to 2 yrs	10
2½ yrs. to 4 yrs	15
5 yrs. to 7 yrs	28
8 yrs. to 10 yrs	18
11 yrs. to 13 yrs	14
Not stated	1

SEX

A review of these cases showed but a slight difference as to sex—there were 52 males and 49 females. Among the 52 boys there were 16 cases in which obstructing lesions were found at or in front of the neck of the bladder, a group of lesions that *does not occur in girls.*

If we deduct these 16 cases the relationship changes slightly in favor of girls, so that we now have 49 girls and 36 boys. The foregoing group of cases associated with obstruction will be discussed further on in this paper.

SIDES INVOLVED

A review of our cases shows but little difference with reference to the frequency with which the right and left side was affected by the hydronephrosis, since there were 31 cases with right-side hydronephrosis and 30 cases with left-side hydronephrosis. Further study, however, showed that there was bilateral involvement in 40 cases, that is, in almost 40 per cent of the cases.

TABLE II.—SIDES INVOLVED

	Cases	Per cent
Right side	31	30.6
Left side	30	29.7
Bilateral	40	39.6

TYPES OF HYDRONEPHROSIS

Hydronephrosis associated with obstructions at or in front of the bladder neck. There were 16 cases of hydronephrosis associated with obstruction at or in front of the bladder neck. The primary consideration was the diagnosis of the nature and location of the obstruction (5). It goes without saying that the treatment for this group of cases of hydronephrosis must be directed toward the relief of the obstruction.

There were 9 patients who had congenital valves in the prostatic urethra. One of the interesting facts about this group of cases was that they were admitted at a much earlier period of life than were the rest of the patients in this group, and furthermore they showed much more extensive hydronephrosis than did the rest of the group.

In the remaining cases the obstruction was due to bars, contractures, and strictures of the urethra. Table III contains the various obstructive lesions found in this group of cases.

TABLE III.—BLADDER NECK OBSTRUCTIONS

	Cases
Congenital valves	9
Stricture of urethra	3
Median bar	2
Contracted bladder neck	2

Fig. 1. Destruction of the kidney due to hydronephrotic atrophy.

As an illustration of a very extensive bilateral hydronephrosis due to congenital valves in the posterior urethra, I should like to present the following case:

CASE 1. Congenital valves in the posterior urethra with associated hydronephrosis.

G. T., male, aged 8 months, was admitted to the Children's Memorial Hospital on August 7, 1935. Complaints on admission to the hospital were difficulty of urination, cloudy urine, and frequency. Three months prior to admission to the hospital the mother noticed that the child would cry every hour at which time he would strain and pass some cloudy urine which apparently relieved him.

Physical examination revealed a pale, thin, colored baby appearing very ill. The child was drowsy. The head, neck, heart, and lungs were negative. Genitalia were negative. Examination of the abdomen revealed a suprapubic tumor that extended one fingerbreadth above the umbilicus and was tense but not painful. The blood count on admission showed red blood cells, 4,730,000; white blood cells, 12,650; hemoglobin, 62 per cent. Urinalysis on admission showed a trace of albumin, 18 to 20 leucocytes, and red blood cells. Blood chemistry on admission showed non-protein nitrogen, 47.1 and creatinin, 1.5.

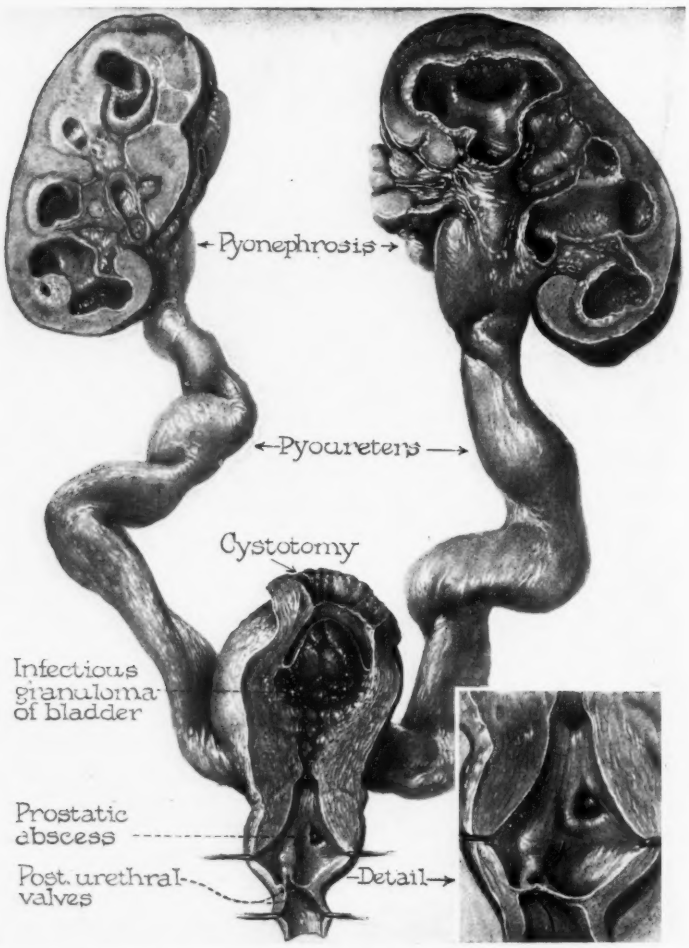

Fig. 2. Case 1. The presence of an enormous, infected hydronephrosis and hydroureter and thickening of the bladder wall due to the presence of congenital valves in the posterior urethra. Insert shows the opening of an abscess in the prostate.

Roentgen-ray examination was negative for stone in the urinary tract. Intravenous pyelograms made on August 13, September 13, and November 11, 1935—no visualization of pelves, ureters, or bladder. Phenolsulphonphthalein test showed an output of 10 per cent of dye in 90 minutes and a total of 30 per cent in 150 minutes.

Operation. A suprapubic cystostomy was done on September 19, 1935. The bladder wall showed an enormous hypertrophy, the mucous membrane was red, and exploration of the internal urethral orifice was negative.

Following the operation the child had a very stormy convalescence and many recurring attacks of pyelonephritis so that at no time was the child in a condition that justified relieving the obstruction due to the presence of valves in the urethra (Fig. 2). The child died on April 8, 1936, 7 months after the cystostomy.

The *anatomical diagnosis* is as follows: Congenital valves in the posterior urethra; hypertrophy of the bladder wall; severe cystitis; infectious granuloma of the bladder mucosa at the site of the suprapubic catheter; bilateral dilatation of the ureters; marked

Fig. 3. Roentgenogram showing a left sided hydronephrosis and hydro-ureter due to a pelvic abscess. Note the filling defect in the cystogram.

bilateral pyoureters and bilateral infected hydronephrosis; disseminated abscesses of both kidneys; left epididymitis; abscesses of the prostate gland; enlargement of the retroperitoneal and periaortic lymph nodes; hypertrophy of the left ventricle of the heart; extreme malnutrition; secondary anemia.

Cystic dilatation of the ureter and hydronephrosis. Although cystic dilatation of the ureter as a cause of hydronephrosis is rare, there were 3 cases in this series in which this etiological factor was present. Two of the patients were girls and one was a boy. The dilatation occurred on the right side in 2 cases and on the left in 1 case. The boy had an obstruction at the bladder neck due to a bar, and in 1 of the girls the condition was associated with a double ureter. These patients were from 3 to 6 years of age.

Foreign body in the bladder and hydronephrosis. In one of our cases the patient

Fig. 4. Roentgenogram showing the outline of the calcified cyst and a right hydronephrosis.

Fig. 5. Bilateral hydronephrosis following ureteral transplantation into the bowel.

Fig. 6. Darkened area shows the enormous size of the hydronephrosis.

Fig. 7. Drawing showing the kink in the ureter and the presence of an enormous hydronephrosis.

developed complete retention following an acute febrile disease, the nature of which was not determined. A tentative diagnosis of acute poliomyelitis had been made. The boy developed complete retention of urine so that it was necessary to catheterize him. (The catheterization was done elsewhere.) When the catheter was withdrawn from the bladder it was noted that a large piece of the catheter was broken off and remained in the bladder, and he was referred to the Children's Memorial Hospital. The presence of the catheter was visualized by roentgen-ray and a set of intravenous pyelograms was made which showed the presence of a slight bilateral hydronephrosis that disappeared after the catheter was removed.

Lesions outside the urinary tract associated with hydronephrosis. It is a well recognized fact that pressure on the ureter from without may result in the production of hydronephrosis. In the adult this is seen in certain lesions of the internal genitalia in women. Because of the rare occurrence of these lesions in childhood, this type of hydronephrosis is very rare. In this series no such case was encountered. On the other hand, there were 2 cases in which lesions outside the urinary tract were associated with hydronephrosis.

In the following case it is obvious that the pathology in the pelvis was a factor in the production of the hydronephrosis.

CASE 2. Hydronephrosis associated with a pelvic abscess.

S. T., male, aged 5½ years, was admitted to the Children's Memorial Hospital on October 4, 1936. The present illness began 2½ weeks prior to admission, with fever and painful urination. It was necessary to void about every 20 minutes and the act was associated with great pain. Several days later pain and soreness developed in the left lower quadrant of the abdomen.

Physical examination revealed the following: The head, neck, heart, and lungs were negative. Examination of the abdomen revealed a palpable mass in the lower left quadrant, apparently taking its origin in the pelvis, and extending about 1½ inches above the margin of the bony pelvis. Rectal examination showed a mass in the left side of the pelvis which corresponded with the abdominal mass described above.

The day following admission, the patient passed a large amount of pus per rectum. Following the rupture of the abscess into the rectum there was a rapid diminution in the abdominal tenderness, the swelling subsided, and the temperature became normal.

Fig. 8. Showing a large soft parts shadow due to hydronephrosis that extends from arch of ribs into iliac fossa. Note complete displacement of intestines to right.

Fig. 9. Intravenous pyelogram showing visualization of only the upper half of a double kidney. Compare with Figure 10.

Examination of urine on admission showed albumin, 2+, many white blood cells, no red blood cells, and no casts. Urine culture showed staphylococcus aureus. The blood count showed 3,700,000 red blood cells, 39,500 white blood cells, and 60 per cent hemoglobin. Roentgen-ray examination was negative for stone in the urinary tract. There was no evidence of bone disease such as osteomyelitis. Intravenous pyelogram revealed the right side to be normal, with a marked hydronephrosis and hydroureter on the left side. Cystogram showed an incomplete filling of the bladder, as though the bladder was compressed by a mass within the bony pelvis (Fig. 3).

In the other case the hydronephrosis was probably an associated finding, since the patient had a tumor of the round ligament of the liver.

CASE 3. Hydronephrosis associated with a tumor of the round ligament of the liver.

C. D., female, aged 6 years, admitted to the Children's Memorial Hospital on October 31, 1935, because of an enlargement of the abdomen.

Physical examination showed the following: The head, neck, heart, and lungs were negative. The abdomen was atonic, flabby, and relaxed; the umbilicus was displaced to the left of the midline. The left flank bulged laterally and superficial veins were

Fig. 10. Retrograde pyelogram showing large hydronephrosis that failed to visualize in the intravenous pyelogram. Compare with Figure 9.

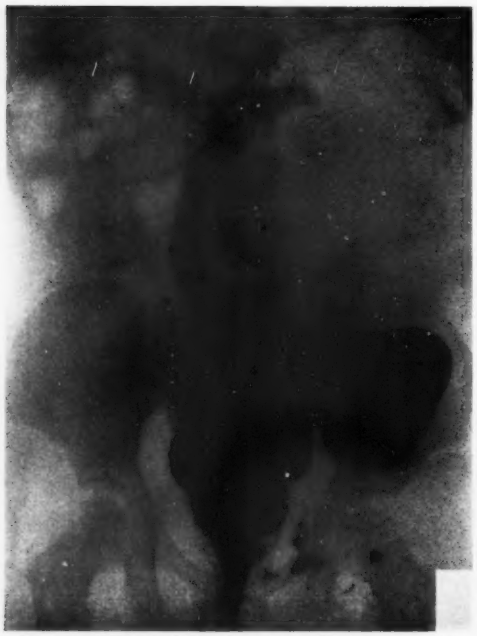

Fig. 11. Note the filling defect and displacement of the colon due to the hydronephrosis.

Fig. 12. Enormous destruction of kidney following plastic operation upon ureteropelvic junction.

Fig. 13. Constriction in pelvic portion of left ureter with dilatation above. The constriction was due to a firm fibrous band. The band was divided by open surgery.

prominent. A large, firm, freely movable tumor, the size of an orange, was noted in the right half of the abdomen.

Roentgen-ray examination revealed an almost spherical density 8.4 by 7.4 centimeters in diameter, in the right upper quadrant, superimposed upon the lateral halves of the eleventh and twelfth ribs. The circumference was made up of a ring of slightly greater density, suggesting that the density was due to a deposit of opaque material (calcification) about a tumor mass most likely made up of fluid or semi-solid material (Fig. 4). The transverse diameters of the lumbar vertebræ increased very rapidly from above downward, and there was slight incomplete fusion of the lamina of the fifth lumbar vertebra and rather broad transverse processes to this vertebra, which were not sacralized.

Intravenous pyelogram showed a right hydronephrosis (Fig. 4).

Examination of the urine on admission showed no albumin, 2 to 4 white blood cells, and was negative on benzidin test. Blood count showed 4,200,000 red blood cells, 10,000 white blood cells, and hemoglobin 80 per cent.

On November 2, 1935, the patient was operated on by Dr. Montgomery who removed a tumor from the round ligament of the liver.

The histological diagnosis was calcified congenital cyst of the round ligament of the liver.

In subsequent intravenous pyelograms the hydronephrosis was still present, hence was not affected by the removal of the cyst.

Stone in the urinary tract associated with hydronephrosis. The association of stone in the kidney and ureter with hydronephrosis is common knowledge although attention may be called again to the fact that patients with relatively large stones in the kidney do not necessarily have associated hydronephrosis. The incidence of stone in the kidney and ureter in association with hydronephrosis for this group of cases is given in Table IV.

TABLE IV.—STONE ASSOCIATED WITH HYDRONEPHROSIS

	Cases
Kidney stones	2
Kidney and ureter stones	2
Kidney, ureter, and bladder stones	1
Ureter stones	3
Total	8

Undoubtedly the incidence of hydronephrosis and stone would have been much larger had either retrograde pyelograms or intravenous pyelograms been made in many of the early cases of stone in the kidney and ureter. I have called attention to this fact in a previous publication (4).

Hydronephrosis associated with lesions of the central nervous system. Lesions of the central nervous system in association with hydronephrosis occurred in 4 cases. Attention has been called by Mertz and Hamer to the importance of spina bifida from the urological point of view. Although hydronephrosis associated with lesions of the central nervous system is rare, both in adults and children, it is important nevertheless, because of the possibility of this association, to bear it in mind since its presence may influence the decision as to the proper treatment for the patient.

In this series hydronephrosis in association with lesions of the central nervous system was found in 4 cases, 3 of them being cases of spina bifida and the other a case of poliomyelitis.

Hydronephrosis following ureteral transplantation. In 2 of the patients in this series, ectopic bladders had been relieved by bilateral ureteral transplantation, one by myself and one elsewhere, and subsequent intravenous pyelograms showed the presence of a slight hydronephrosis in each case (Fig. 5).

Hydronephrosis and congenital anomalies of the kidney and ureter. Before the days of modern urologic diagnosis, renal anomalies were thought to be rare, and for all practical purposes were the subject of autopsy reports only. As more and more patients were subjected to careful urologic study, it soon became apparent that renal anomalies occur much more frequently than had been supposed. The same statement can be made regarding renal anomalies in childhood. And finally, since the advent and more frequent use of intravenous urography many more congenital anomalies are found both in adults and children. An interesting paper dealing with the frequency of congenital anomalies found at autopsy in children was recently published by Bigler (2).

The fact that a kidney which is the seat of congenital anomalies is more apt to become the seat of pathological changes than a normal kidney is a well recognized fact. Therefore, it was extremely interesting to study this group of cases from that point of view. However, in 2 of our cases the congenital anomaly occurred on one side and the hydronephrosis on the other.

The developmental kidney and ureteral anomalies for this series are given in Table V.

TABLE V.—CONGENITAL ANOMALIES

	Cases
Double kidney and ureter	5
Double kidney (right) and bifid pelvis (left)	1
Double kidney and ureter (left), bifid pelvis (right)	1
Bilateral double kidney and ureter	1
Solitary double kidney	1
Double kidney and ureter with cystic dilatation of the vesical end of the ureter	1
Double kidney and ureter with opening of the accessory ureter below the external urethral orifice	1
Bifid pelvis	1
Bilateral bifid pelvis	1
Bifid pelvis with cystic dilatation of the vesical end of the ureter	1
Solitary kidney	1
Incomplete rotation of kidney	2
Congenital dystopia of kidney with aberrant artery	1
Aberrant artery	1
Bipolar blood supply	1
Renal infantilism	2
Congenital cystic kidney	1
Cystic dilatation of vesical end of ureter	1
Total	24

In other words, renal anomalies were found in 24 cases, or 23.7 per cent.

SYMPTOMS

There is no typical symptom-complex of hydronephrosis. The symptoms may at times be due to the underlying pathological condition that is responsible for the development of the hydronephrosis, such as stone, or obstruction at or below the neck of the bladder. Occasionally the hydronephrosis runs an apparently silent course and is discovered only on routine urologic examination.

1. In my experience the largest number of cases presented themselves with a clinical picture of acute or chronic *pyelonephritis*. In many of the patients, although the hydronephrosis was relatively large, attention had not been called to the urinary tract until after the onset of infection. In many of the patients a history of recurring attacks of pyelonephritis and the presence of a chronic pyuria following one or more attacks of acute pyelonephritis led to a complete study of the urinary tract and this study demonstrated the presence of hydronephrosis. It is because of this fact that all children who have a history of recurring attacks of pyelonephritis, or in whom the pyuria following an attack of acute pyelitis does not clear up, should be subjected to a complete examination of the urinary tract to determine the reason for the so called chronic pyuria. The largest number of cases that form the basis of this paper fall into this group. It was interesting to note the frequency with which the infection of the urinary tract followed an infection in the nose, throat, and sinuses, or followed in the wake of one of the acute infectious diseases.

2. *Tumor.* In some of the patients the first indication of hydronephrosis was an abdominal tumor—that is, the mother of the child noticed a gradually increasing size or swelling of the abdomen, which generally was painless. According to the mother's observation, the size of the abdomen may seem to vary, appearing larger at one time than at another. Although in this series of cases the number of patients admitted to the hospital because of an abdominal tumor was small, I should like to report one of the cases in which the size of the hydronephrosis was the largest I have ever seen in a child. It occupied the entire left half of the abdomen and reached to the nipple line on the right side (Fig. 6). Due to the enormous size of some of these hydronephroses one is inclined to believe that they have been present for a long time. The case I am about to report, however, is that of a patient of only 7 months of age and the swelling of the abdomen was noted at the age of 2 months. In a certain number of cases pain is a symptom in these tumor cases due to an infection in one of the kidneys.

CASE 4. Large silent hydronephrosis.

G. D., male, aged 7 months, admitted to the Children's Memorial Hospital on May 25, 1936. The mother had first noticed a swelling of the baby's abdomen when he was 2 months of age. This had been particularly noticeable when the child would sit up and the mother believed that the swelling had become progressively larger. There were no urinary symptoms. Enemas had had no effect on the size of the abdominal swelling. The mother had noted that the abdomen was enlarged and "stuck out" on the left side. She was of the opinion that during the last 3 months the enlargement had progressed very rapidly.

Physical examination revealed a well developed, well nourished child, apparently not acutely ill. Eyes, ears, nose, throat, lungs, and heart were normal. On examination of the abdomen a mass was felt in the left side which apparently originated from under the costal arch and extended downward below the left anterior spine. In the midline it extended almost to the symphysis pubis and on the right to the nipple line. The mass was neither painful nor tender and the impression derived was that it was soft (Fig. 6). Urinalysis on admission was negative for albumin, blood, and pus. Blood count showed 4,500,000 red blood cells, 21,250 white blood cells, and 75 per cent hemoglobin. Blood chemistry showed non-protein nitrogen 35.4, urea nitrogen 14.8. Roentgen-ray examination was negative for stone. A large soft tissue shadow was seen. Intravenous pyelogram showed a normal pyelogram on the right side. There was no visualization on the left side.

Operation. Left nephrectomy. A large hydronephrotic kidney was removed (Fig. 7).

3. In the group of cases in which the hydronephrosis is due to *obstruction* at or in front of the bladder neck, the clinical picture is that of vesical neck obstruction. Difficulty in urination, straining, a small weak stream, dribbling, and suprapubic tumor make the diagnosis relatively simple. When infection

occurs, the clinical picture of acute pyelonephritis is superimposed upon or added to the bladder symptoms.

As has already been mentioned, the general symptoms, in a very large number of cases, completely dominate the clinical picture, hence the urinary pathology is not only overshadowed but overlooked by the attending physician, with the result that often when the patient is admitted to the hospital irreparable damage has already been done to one or both kidneys. Nevertheless, urinary changes can be readily ascertained if repeated examinations of the urine are carried out.

In Table VI a list is given of the symptoms presented by the patients (101) who form the basis of this paper.

TABLE VI.—SYMPTOMS

	Cases
Fever	67
Pain	54
Pyuria or cloudy urine	54
Nausea or vomiting	45
Frequency	40
Pain on urination	25
Incontinence	20
Nocturia	20
Chills	20
Gastro-intestinal upset	18
Poor appetite	18
Hematuria	16
Burning on urination	16
Enuresis	16
Difficulty	16
Headaches	16
Loss of weight	15
Dribbling	9
Urgency	7
Irritability	4

DIAGNOSIS

If the possibility of hydronephrosis is borne in mind in those cases in which a child presents a history of recurring attacks of pyelitis or in cases of persistent pyuria which fails to respond to medical management accurately carried out, the proper diagnosis could be made more frequently than it has been in the past and at a much earlier period in the course of the disease.

A history of rapid enlargement of the abdomen should be given due consideration and also of great importance is the mother's observation that the tumor has varied in size from time to time. A long-standing history of symptoms compatible with obstruction at or in front of the bladder neck should always arouse our suspicions of the possibility of hydronephrosis being present.

The physical examination in cases with small hydronephrosis is negative. On the other hand, physical examination may show the presence of a large swelling in the renal area. This may or may not be associated with pain or tenderness. A palpable kidney or a mass in the kidney region was found in 22 cases.

Roentgen-ray examination should be carried out in each patient. This may or may not show an enlargement of the kidney. In one of our cases the outline of hydronephrosis was demonstrable in the plain roentgen-ray film (see Fig. 8). Roentgen-ray, outside of showing changes in the kidney outline and stones when present, does not furnish one with much diagnostic information.

The intravenous pyelogram probably has its greatest field of usefulness in this group of urological conditions. Great care, however, must be exercised in the interpretation of the films, and it is needless to emphasize that, when doubt arises, a retrograde pyelogram is always in order. Failure of the dye to visualize the kidney must be interpreted with the greatest care. An interesting example of this is the pyelogram of a patient in which the upper half of a double kidney (Fig. 9) visualized and was normal although there was no visualization of the larger lower half due to the fact that the lower and larger half of the kidney had undergone complete hydronephrotic atrophy; the embryonic upper half was normal. The diagnosis which was made in this case was verified by a retrograde pyelogram (Fig. 10).

The cystoscopic examination, except in the cases of bladder neck obstruction, adds nothing to the diagnosis. However, cystoscopic examination and ureteral catheterization for evidence of pathology as well as for the demonstration of function, normal or otherwise, on the other side must be done before surgical intervention is carried out.

The statement has been made many times that the patient suffering from hydronephrosis often has a normal urine; it is because of this

fact that the condition is overlooked for a long period of time, so that irreparable damage to the kidney has already occurred when the patient comes under observation. While hydronephrosis may occur in a patient with normal urine with relative frequency in the adult, and while this statement has been made with relative frequency concerning children, such has not been my experience. It may be that the patients in this group may have presented a different clinical picture than the patients in another group. However, in the study of these 101 cases from the point of view of urinary findings, it was exceedingly interesting to note that pus, at one time or another, was found in 97.8 per cent of the urines examined. In other words, in approximately 98 per cent of these patients either pus was present in the urine when the patient came under observation or pus had been found by the physician before the patient came to the hospital. An analogous statement may be made for the presence of other abnormal elements. The next most common element was albumin and this was noted in 68 per cent of the cases. Table VII gives the results of urinalysis for the series.

TABLE VII.—URINALYSIS

	Per cent
Pus	97.8
Albumin	68.8
Red blood cells	47.3
Gross blood	30.1
Casts	17.2
Normal urine	2.1

BACTERIOLOGY

In some of the early cases no bacteriological studies were carried out, and in others no records of bacteriological studies are at hand —whereas in another group of patients, those seen in consultation, the referring physician had not carried out cultural studies of the urine.

A review of the cases in which bacteriological studies were made shows that colon bacilli either alone, or in association with other organisms, were found in 47.9 per cent of the cases. The various types of organisms found in the bacteriological studies are given in Table VIII.

TABLE VIII.—BACTERIOLOGY

	Per cent
Bacillus coli	47.9
Staphylococcus albus	27.3
Staphylococcus aureus	9.5
Streptococci	9.5
Bacillus pyocyaneus	6.8
Eberthella	2.7
Gram negative bacilli	2.7
Diplococcus	2.7
Bacillus proteus	1.3
Bacillus alkal	1.3
Streptococcus viridans	1.3
Bacillus pyogenes albus	1.3
Enterococcus	1.3

DIFFERENTIAL DIAGNOSIS

Of great importance in the differential diagnosis is the determination of underlying factors or symptoms that make for the presence of hydronephrosis. This includes, in the first instance, a determination of the infravesical and supravesical causes of hydronephrosis.

Of the various lesions of the kidney that call for differential diagnosis are acute and chronic pyelonephritis, tuberculosis, stone, and tumor.

Hydronephrosis may, at times, be confused with other retroperitoneal lesions, and since some of the cases present gastro-intestinal symptoms, lesions of the gastro-intestinal tract must be borne in mind in this particular group of cases.

That hydronephrosis by its size may be confused with gastro-intestinal conditions because of its effects was illustrated in one of our patients in whom the gastro-intestinal examination showed displacement and a filling defect in the colon (Fig. 11).

PROGNOSIS

My experience with the subject of hydronephrosis in infancy has impressed me with the fact that a large number of patients have come under observation late in the course of the disease—that is, at a time when far advanced destruction of the kidney had occurred. There seem to be several reasons for this, foremost of which is the failure on the part of the attending physician to interpret the sequence of events and the failure of clinical diagnosis, so that when many of these patients are seen by the urologist there is already a complete or almost complete destruc-

tion of the kidney and only a nephrectomy can be offered to the patient. On the other hand, in some of the early cases, in which the patient was seen early in the course of the disease and the contributing factor removed, the results were brilliant.

TREATMENT

The treatment depends upon the underlying contributing factors. The cases of obstruction at or in front of the bladder neck call for suitable correction, namely dilatation of strictures of the urethra, destruction of congenital valves, either by means of fulguration through the urethroscope or surgery, relief of bladder neck obstruction with a resectoscope or open surgery.

The group of cases in which the condition is due to stricture at the vesical end of the ureter require repeated dilatation by means of the cystoscope and ureteral catheter followed by pelvic lavage, which has proved eminently satisfactory in a large number of cases.

Attention should be called at this time to the small group of cases in which this form of treatment was followed by severe infection of the kidney. In one instance an immediate nephrectomy was necessary to save the life of the patient. This patient had a stricture not only in the vesical end of the ureter but also at the ureteropelvic junction.

When a stricture is present at the ureteropelvic junction associated with infection, the treatment is indwelling ureteral catheter, dilatation, and pelvic lavage, before surgery is resorted to.

The surgical treatment may best be discussed under conservative surgical measures and radical surgery. Conservative operation carried out in this group of cases consisted of plastic operation at the ureteropelvic junction. Included were the division of an aberrant artery, nephro-ureterolysis, and the various plastic operations, such as excision of the stricture and implantation of the ureter into the kidney pelvis. As previously mentioned, in the past a large number of these patients came in with far advanced disease, so that the only possible procedure was nephrectomy.

Of the number of patients operated upon, nephrectomy was carried out in 18 cases. In one of the patients upon whom a plastic operation was done, the operation failed to relieve the symptoms. Following the operation the patient ran a very stormy convalescence and became very septic, so that it was necessary to remove the kidney 10 days after the plastic operation on the kidney pelvis (Fig. 12).

In one of the cases the hydronephrosis was due to compression of the ureter by a very thick fibrous band (Fig. 13). The ureter was exposed extraperitoneally and the fibrous band divided and excised.

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THE FREQUENCY OF CONCEPTIONS IN FAMILIES HAVING CONGENITALLY MALFORMED CHILDREN

A Study of 208 Consecutive Families

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THE underlying cause of congenital malformations remains obscure, though recent studies indicate that they occur with unusual frequency under certain conditions. For example, defects appear especially close to the time that miscarriages (including abortions), stillbirths, and premature births take place (1); more often in families possessing a malformed child than in ones having none (2); more frequently in later than in earlier born siblings (6); more often when the mother is old than when she is young (3). On the other hand, a wide difference in the ages of the parents does not seem to be a predisposing factor (5).

When formulating the above observations the following question arose: Do parents tend to reproduce unusually frequently prior to the birth of their defective children? If they do, then it might be inferred that rapidly repeated childbearing possibly is another predisposing cause of congenital defects. The present report deals with this subject.

MATERIALS AND METHODS

To quote from a previous publication (6), the data forming the basis for the present report were collected in the following manner:

There were found in the files of the Bureau of Vital Statistics, Department of Health of the State of Pennsylvania, 130,132 death certificates for stillborn and liveborn individuals who died in Philadelphia during the 5 years between January 1, 1929, and December 31, 1933. Each of these certificates was examined, and the data on those noting the existence of any congenital defect were transcribed to duplicate official forms; 1,476 such certificates were located.

The deceased individual was considered to have possessed a defect under either of two conditions: (a) if the defect involved the surface of the body, or (b) if internal, if its presence had been disclosed by operation or necropsy. Diagnoses not conforming to these requirements were considered as not verified and were excluded from further consideration. This procedure reduced the number of usable certificates to 890, or only 60 per cent of the original 1,476 certificates.

An attempt was made to interview the mother of each of the 890 deceased individuals, the visits being made in the summer of 1934 by 3 fourth-year medical students. A complete reproductive history was secured from each mother who could be located. The group forms a consecutive series. The defective children all died within a given geographic area and a given period of time.

Among the families offering complete reproductive data, 208 were found suitable for a study of reproductive frequency. This number included all families having 2 or more conceptions prior to the birth of the malformed child, in each of which families both the month and year of each conception was known, as well as the month that each pregnancy terminated.

The frequency of reproduction was computed in the following manner: The total reproductive period, prior to the conception of the malformed child was defined as the interval, in months, between the conception of the first offspring and the birth of the last one. The interval between the latter and the conception of the defective child was omitted purposely. This was because many of these women exhibited at this time extremely long periods of relative sterility (4), and therefore to include this period in the total reproductive interval would only have complicated matters.

The duration of the reproductive period in months was divided by the number of intervening full term pregnancies and fractions of the same, in order to determine the average number of months utilized by each pregnancy. The resulting numerical value made possible a comparison of the rapidity of childbearing in defective and in control families.

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TABLE I.—DIAGNOSIS OF MALFORMED CHILD

Chief Diagnosis	Number of families
Hydrocephalus, spina bifida	99
Anencephalus	20
Heart defect	17
Meningocele	13
Pyloric stenosis	11
Monsters, undescribed	10
Intestinal defect	9
Hare lip, cleft palate	9
Hernias	6
Mongolism	4
Other defects	10
Total	208

The chief defects in the malformed children in 208 families, studied with respect to the frequency of childbearing prior to the birth of the defective sibling.

Similar data were secured for an approximately equal sized series of control families containing all normally developed offspring. These families were approximately the same size as the defect bearing families. The control families were located in the out patient departments of the University of Pennsylvania Maternity, and the Woman's Clinic, Pennsylvania Hospital, the latter through the courtesy of its director, Dr. Norris W. Vaux.

TABLE II.—SIZE OF FAMILY

Pregnancies	Defect		Control	
	Families	Preceding normal offspring	Families	Normal offspring
(1)	(2)	(3)	(4)	(5)
2	61	122	70	140
3	42	126	53	159
4	29	116	42	168
5	19	95	23	115
6	22	132	20	120
7	12	84	10	70
8	10	80	1	8
9	3	27	8	72
10	4	40	3	30
11	2	22	1	11
12	3	36	0	0
13	1	13	0	0
Totals	208	893	231	893

Column 1, the number of pregnancies preceding the birth of the malformed child in 208 families. Column 2, the number of defective families by size. Column 3, the number of preceding normally developed offspring. Column 4, the number of control families by size. Column 5, the number of offspring in control families. Note in Columns 2 and 4 the close resemblance in families by size, and in Columns 3 and 5 the identity in the number of offspring in defective and in control families.

THE DATA

The chief defect of the malformed child in each of the 208 families mentioned above, is recorded in Table I, and the sizes of these families in Table II.

According to the described method of computation, each pregnancy in the defect bearing families utilized an average of 220.0 months, whereas each pregnancy in the control families utilized an average of 218.9 months. The difference between these two figures, 1.1 months, is so slight that it appears to have little if any statistical significance. Furthermore, if the figures represent a true random sample, they suggest that the defect bearing families reproduced more slowly than did the control families. From these observations it might be concluded that rapidly repeated childbearing is not a predisposing cause in the production of congenital malformations.

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A CLINICAL STUDY OF CATGUT IN RELATION TO ABDOMINAL WOUND DISRUPTION

With a Test of its Tensile Strength on Patients

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THE age of the patients in the series of disruptions at the University of Chicago Surgical Clinic varied from 2 months to 74 years. The distribution of cases by decades is given below.

Age in years	Cases	Age in years	Cases
0– 9	3	40–49	7
10–19	0	50–59	9
20–29	1	60–69	8
30–39	2	70–79	6

The greatest number of patients were in decades beyond the fourth. Three patients were infants 2 to 4 months of age. In the adult group there were 33 cases in which the average age was 56 years. Only 5 of these patients were under 45 years of age. Of the 28 patients over 45 years of age 10 were operated upon for non-malignant lesions.

As to *sex* there were 28 males and 8 females in the series, a ratio of 3½ to 1. This survey did not include the gynecology service.

Primary disease. Malignant disease of the abdominal viscera was the most frequent condition necessitating operation. Of the 19 malignancies there were 10 cases of carcinoma of the stomach. Table I shows the distribution of cases from the standpoint of the underlying disease.

Operation. The distribution of cases in relation to the operative procedure is presented in Table II. In addition, the incidence of disruption for a number of the standard operative procedures was calculated from the data on the total number of operations performed and listed in the operative index maintained in the record library (18). The magnitude of the operative procedure appeared to have some influence on the incidence of disruption. On the other hand, the nature of the underlying disease in some instances altered the incidence considerably as may be noted under gastrectomy and gastrojejunostomy. From the wide variation in incidence which has been observed for different operations and diseases it would appear that any estimation of the relative incidence in a large series of consecutive laparotomies would be of little value unless the nature of the operation and the disease was known.

Incision. An upper abdominal vertical incision was used in 26 cases, a lower abdominal in 9 cases, and a loin incision in 1 case. Transverse incisions were seldom used except for an occasional umbilical hernia or as a supplement to a vertical incision in difficult stomach or spleen cases. No disruptions occurred in these instances or following a McBurney incision. The latter incision has usually been the approach to the acute appendix unless there is some question of diagnosis. A cigarette drain was brought out through the incision in 7 of the cases.

Exciting cause. The presence of postoperative complications which would be responsible for an increased amount of strain on the incision was noted in most of the cases. In 19 cases distention and vomiting were conspicuous features. In 5 cases a severe cough was apparently a factor of importance. One patient decided to get out of bed on the second day after cholecystectomy and the wound broke open the following day, while another with similar intentions thrashed about in his restraints and disrupted on the fourth day after cholecystectomy.

Symptoms. In 5 cases the symptoms suggestive of acute intestinal obstruction led to careful inspection of the wound and removal of some of the skin sutures to permit observation of the deeper part of the wound. Small bowel was found to have herniated through the sepa-

From the Department of Surgery of the University of Chicago.

TABLE I.—DISEASE NECESSITATING OPERATION

	Cases	Total
Carcinoma		19
Stomach	10	
Rectum	4	
Pancreas	3	
Colon	2	
Liver and biliary tract		7
Cholelithiasis and chronic cholecystitis. (1 complicated by choledocholithiasis) (1 associated with duodenal ulcer)	5	
Cirrhosis of liver	2	
Peptic or acid ulcer		3
Stomach	1	
Duodenum (uncomplicated)	1	
Jejunum (postoperative)	1	
Tuberculosis		3
Kidney	1	
Spleen	1	
Duodenum	1	
Appendicitis (ruptured, gangrenous)		2
Intussusception		1
Hypertrophic pyloric stenosis		1

TABLE II.—DISRUPTIONS

Operation	Disruptions	Total cases	Incidence per cent
Gastric surgery			
Gastrectomy (for)	8	97	8.3
Carcinoma	6	60	10
Peptic ulcer	1	27	3.8
Other conditions	1	10	10.
Gastrojejunostomy (for)	4	134	3.
Carcinoma	3	34	8.8
Peptic ulcer	1	100	1.
Gastrostomy	1	32	3.
Closure of gastrojejunostomy	1	15	6.7
Pyloromyotomy	1	21	4.7
Biliary surgery			
Cholecystectomy	3	312	0.96
Cholecystectomy and choledocholithotomy	1	26	3.8
Cholecystenterostomy	1	4	25.
Combined gastric and biliary surgery			
Gastrojejunostomy and cholecystectomy	1	7	14.3
Gastrojejunostomy and cholecystgastrostomy	1		
Intestinal surgery			
Proctectomy (combined abdominal-perineal)	3	30	10
Colectomy by exteriorization (Mikulicz)	2	27	7.4
Reduction of intussusception	1	5	20.
Colostomy	1	51	2.
Miscellaneous surgery			
Exploratory laparotomy	3	76	4.
Appendectomy	2	966	.2
Nephrectomy	1	137	.7
Splenectomy	1	12	8.3

rated fascia in these instances. This condition would have been overlooked if the intact skin had not been separated. In a number of cases the presence of a copious serosanguineous drainage on the dressings was the first suggestion of disruption. In a few instances the patient mentioned feeling something give way in his abdominal wound, which subsequent observation of the wound confirmed. In many of the cases the presence of disruption was noticed only when the dressings were changed and the separation of the skin edges observed. This was often shortly after the removal of the skin or tension sutures.

Day of disruption. The average time of disruption was the ninth day. The earliest was the day after operation in an infant closed with silk. The latest was the twentieth day in a patient who had a cholecystectomy and removal of common duct stone. The average day of disruption for the clean cases was the seventh, while the average for the infected cases was the twelfth day. The ninth day was the average for cases in which non-absorbable suture material was used for the fascia. The clean cases in which 20-day chromic catgut was used averaged 7.8 days.

Suture material. The closure of the anterior sheath of the rectus was done with linen in 4 cases, and silk in another. A continuous suture of No. 2 20-day chromic catgut was used in 27 cases, and No. 0 20-day interrupted was used in 2 infants. A No. 2 40-day catgut was used in 2 cases. Silkworm tension sutures usually supplemented the closure.

Pathology. The condition of the wound at time of disruption was that of gross infection in 13 cases. In this group there were 2 cases of high intestinal fistula and 1 case of infected biliary fistula to complicate the situation. There were 23 cases which were classified as clinically clean, although bacteriological study which would substantiate this classification was not done. There were a number in this group which no doubt had some degree of a low grade or non-suppurative type of infection.

On inspection of a supposedly clean disrupted wound one was often at a loss to identify fascial landmarks. There was frequently some fibrinous exudate on the exposed viscera

and wound edges. Frequently the wound edges were very friable. In some instances, however, the wound looked very much as though a fresh incision had just been made. A marked degree of catgut digestion was noted in most of the cases, regardless of whether the wound was clean or infected. There were 9 cases in which intestine prolapsed through the incision. One of these cases was somewhat atypical. On the second day following a colostomy it was found that the large bowel had pulled back into the abdomen and small intestine had prolapsed through the opening in the abdominal wall. Fortunately, the colostomy had not been opened. In another case which was a Mikulicz colectomy the stumps of the bowel retracted after removal of the exteriorized portion. Small bowel prolapsed through the defect in the abdominal wall which had been occupied by the stumps of colon. In this instance the accident was discovered before the proximal stump of bowel had emptied any fecal material into the peritoneal cavity.

Treatment. An immediate secondary closure with through and through silkworm gut or heavy silk was done in 29 cases. This was supplemented by a layer suture of catgut in a few cases when the condition of the wound would permit. Adhesive strapping was done in 4 cases. A delayed secondary closure was done in 3 cases after subsidence of the acute infection of the wound. One case eviscerated a second and third time after repeated secondary suture. Finally adhesive strapping was done, but the infant eventually succumbed.

Mortality. There were 13 deaths in this series of 36 disruptions, a mortality of 36 per cent. In the group of 23 cases which were classified as clinically clean wounds, the mortality was 26 per cent. In the series of 13 grossly infected cases the mortality was 54 per cent. In evaluating the rôle of disruption in the fatal cases, it was rather interesting to find that 8 of the patients undoubtedly would have had a fatal outcome regardless of disruption of the wound. In 3 cases the disruption was no doubt a contributing factor of some importance, the extent of which would be difficult to evaluate. There were 2 cases in which the lethal outcome was apparently due primarily to the disruption.

REVIEW OF THE DATA ON 1294 CASES OF ABDOMINAL WOUND DISRUPTION

An endeavor has been made to summarize the data available in the literature on cases of wound disruption. This is presented in Table III. Conclusions pertaining to the etiology of this condition are incorporated in the discussion of factors influencing disruption.

The first comprehensive report was published by Madelung in 1905. He reviewed 157 cases including 13 which he and his associates had observed. Half of the cases were following gynecological operations. The first report of several cases in the American literature was that of Brettauer in 1899. Ries gave an account of 6 cases in 1909. In 1925 Holterman reviewed 15 cases which represented an incidence of 2 per cent in the series of operations performed. In the same year Shipley described a method of secondary closure of disrupted wounds by the use of silver wire which could be tightened up over buttons. The cases presented illustrated the efficacy of this procedure in the treatment of a condition which obviously constituted a problem of therapy of greater magnitude than the 5 cases which were treated successfully would appear to indicate.

In 1928 von Gusnar reported 11 cases. In the following year Horner described 3 cases following cesarean section which constituted an incidence of 0.3 per cent. Monod and Kiraly mentioned 6 cases in 1929. Sigalas reviewed 8 cases in 1932. The most comprehensive article on disruption appeared that same year by Sokolov. The data on the 723 cases which he reviewed were obtained from many European surgeons and even included 19 cases from the New York Presbyterian Hospital. In 1933 McCauliff reported 3 cases, and Starr and Nason reviewed 15. In the latter review there were 6 disruptions in 135 operations for carcinoma which made an incidence of 4.4 per cent as compared with 61 per cent for the entire series of operations performed.

The symposium on disruption conducted by the New York Surgical Society in 1933, which was instigated largely by Dr. W. Crawford White, was the most important factor in drawing to the attention of the American surgical

TABLE III.—SUMMARY OF DATA ON 1294 CASES OF ABDOMINAL WOUND DISRUPTION

	Cases	Incidence—per cent	Age—average	Males	Females	Malignancy	Biliary	Appendicitis	Ulcer	Ileus	Gynec. & Obst.	Upper incision	Lower incision	Drainage	Infection	Disruption day	Deaths	Mortality per cent
Jenkins	36		56	28	8	19	7	2	3	1	0	26	9	7	13	9	13	36
Bettman and Lichtenstein	32	.43	44	10	22	6	6	1	2	4	13	11	21	3	4	7.9	12	38
Glasser	8	.24	48	6	2	0	2	0	3	0	1	7	1	4	3	8.8	5	63
Milbert	20	1.3	53	17	3	8	7	0	3	0	2	13	3	9	7	8.3	11	55
Koster and Kasman	17	.22	49	13	4	2	4	5	4	0	1	10	6	7	6	7.8	3	18
Maes, Boyce and McFetridge	44		32	21	23	5	2	10	1	3	8	11	33	10	9		13	30
Eliason and McLaughlin	25	.27		19	6	6	6	1	11		0	22	3	8	6	6.1	8	32
Meleney and Howes	56*	1	51	41	15	19	16	6	5	3	1	35	17	29	35	7.5	30	54
Colp	29	.9	42	14	12	8	7	5	0		5	10	14	13			8	28
Grace	46					10	8	7	11	2	0	39	7		17	7.6	18	39
White	33*		46	23	10	6	6	3	9	2	0	19	12	10	10	8.7	18	55
Heyd	8	.25															2	25
Starr and Nason	15	.61	47			5	2	3	0	1	4	6	9					
McCauliff	3		49	2	1	1	0	1	0	0	1	1	1	0	0	8.3	0	0
Horner	3	.3	34	0	3	0	0	0	0	0	3	0	3	0	0	7.3	0	0
Shipley	5			5	0	1	1	0	0	1	0	3	2			9.6	0	0
Ries	6		40	2	4	2	0	1	0	0	2	2	4	0		8.5	1	17
Brettauer	3		41	0	3	0	0	0	0	0	3	0	3	0		6.	2	67
Total American cases per cent	389		46	201 63	116 37	98 26	74 19	45 12	52 14	17 5	44 12	215 59	148 41	100 31	110 34	8.	144	39
Sokolov per cent	723	2–3	43	407 63	239 37	169 27	63 10	29 5	120 19	57 9	94 15	229 58	167 42	49 9	93 15	8.4	226	34
Sigalas	8		43	3	5	1	0	1	0	0	5	2	6	2	1	9.8	1	14
Monod and Kiraly	6		43	1	4	1	0	0	1	0	2	3	3	0	0	10.	0	0
von Gusnar	11	.41	55	11	0	5	1	0	2	1	0	9	2	2	4	11.3	8	73
Madelung	157		42	25	118	21	0	2	1		80	16	124			8.5	35	23
Total or average per cent	1294		44	649 57	482 43	296 25	138 12	77 6	176 15	75 7	227 18	474	450	153 17	208 22	8.3	414	35

Note.—*The data on the cases reported by White and Meleney and Howes has been supplemented by additional information.
The cases reported by Holterman were omitted because they were incorporated in the review of Sokolov.
The American cases were listed together in reverse chronological order and summarized to permit comparison with the large series of Sokolov.
The averages or percentages given in the table were calculated on the basis of the number of cases in which the data for that column was available. This did not correspond with the total number of cases reported in each instance.

profession the prevalence of this postoperative calamity. The papers of Meleney and Howes, Colp, Grace, White, and Heyd, which were published the following year, constitute a conspicuous landmark in the study of disruption. Later in 1934 Maes, Boyce, and McFetridge reported 44 cases, of which 6 were following a McBurney incision. At about the same time Eliason and McLaughlin reviewed 25 cases. The article by Milbert in 1935 reviewed 20 cases and presented interesting data on intra-abdominal pressure. The series of 17 cases discussed by Koster and Kasman in 1936 was the first large group from a series of operations performed under spinal anesthesia. The most recent articles are those of Glasser and of Bettman and Lichtenstein. These appeared simultaneously.

FACTORS INFLUENCING DISRUPTION

Factors attributable to the surgeon and his technique. Knot tying. Remarks pertaining to

elementary principles of surgery, such as the technique of tying a knot, seem out of place except in a textbook of surgery. On the other hand, there are several points which deserve mention at least for the benefit of assistants who are frequently called upon to close the abdomen for the operating surgeon. When a knot is tied down too tightly in the fascia it may later pull through the tissue as a result of pressure necrosis. If the knot is tied poorly or if the free end is cut too close to the knot, a relatively slight amount of tension may result in the loosening of the knot. A boilable catgut which has not been made adequately pliable by exposure to moisture is very difficult to tie securely. The points mentioned are of particular significance when a continuous suture is relied upon to maintain apposition of the fascia.

Amount of catgut and hemostasis. Large amounts of large size catgut for ligatures and sutures, and mass ligature which devitalizes considerable tissue will result in an undue amount of serous accumulation in the wound. Failure to control bleeding adequately may result in a hematoma. The presence of excess serum or a hematoma has been shown by Howes (13) to predispose to infection and hasten the digestion of catgut.

Drainage. In the American series of disruptions a third of the reported cases were drained. When the European cases, except those of Madelung, are also considered, it is found that one-sixth of the total cases were drained. Colp found that the incidence of disruption was 1.22 per cent in a series of 1,147 drained cases as compared with 0.84 per cent in 1,603 laparotomies in which there was no drainage. The use of a drain usually implies the presence of suppuration, except in instances in which the drainage is a precautionary measure as in cholecystectomy. It is a question whether the presence of intraperitoneal infection is not of more significance as an etiological factor than the drain itself.

The technique of closure in the presence of a drain may influence the incidence of disruption to some extent. The use of a continuous suture would seem to be especially undesirable. The presence of intraperitoneal suppuration would no doubt lead to infection of the tissue in proximity to the drain. The continuous suture which is tied adjacent to the drain would undergo rapid digestion in the presence of the infection at this point, and the continuity of the suture would be lost long before adequate healing had occurred in the rest of the wound. It would appear to be safer to use a separate stab incision for drainage whenever this is feasible. If the separate point of drainage is not feasible one should at least put in several interrupted sutures adjacent to a drain before beginning a continuous suture for the rest of the wound. An additional point illustrating the disadvantage of a continuous suture in the presence of a drain, even when it is not used for intraperitoneal suppuration, is taken up in the discussion of the tests conducted on catgut.

Tension sutures. The use of tension sutures as a supplement to a catgut layer suture has been frequently recommended, especially in instances when the surgeon might anticipate delay in wound healing or early digestion of catgut from infection. There are some features about the use of tension sutures in wounds closed with continuous catgut which deserve analysis from a purely mechanical point of view. If a tension suture is tied too loosely it will not give any support to the wound unless the underlying fascia separates. Then its support is mainly that of the skin and subcutaneous tissue. It would help prevent evisceration but would not impede separation of the fascia. If the tension suture is tied too tightly it is usually observed to cut through the skin. It no doubt cuts through the anterior sheath to some extent at the same time. It is not difficult to visualize the tightly tied tension suture also cutting through a continuous suture in the anterior sheath. If the tension suture is tied in such a way that it gives some support to the wound without falling into the category of being too tight, even then it may be harmful to a continuous suture in the anterior rectus sheath. The mechanics involved in this situation, as pointed out by Meleney, appear to be similar to a lateral pull on either side of a wire loop. Under such circumstances the circle changes to an oval in shape with decrease in the vertical diameter, which depends on the amount of force ex-

erted. The effect of lateral force on a wound would tend to flatten out a circular tension suture. Thus there would develop downward force against the skin and upward force against the anterior sheath. Depending on the strain exerted on a wound the tension suture would then be expected to cut through the skin and fascia to some extent. In cutting through the fascia it would also interrupt the continuity of the suture in the anterior sheath. The use of U-shaped tension sutures instead of the circular type would not necessarily prevent it from cutting through the fascia when tied too tightly or when any strain is put on the wound. Judging from these purely mechanical aspects it does not seem appropriate to use a continuous suture in the presence of tension sutures. An additional point in support of this is brought out in the discussion of the interpretation of the seton test. If one does use tension sutures with continuous catgut, it would seem preferable to put them in sufficiently close together so that they would constitute adequate approximation of the wound irrespective of the catgut.

Factors attributable to the patient. Delayed wound healing. The effect of malignant disease in retarding wound healing is a common observation. Malignancy is undoubtedly an important factor in the etiology of disruption as evidenced by its frequency of 25 per cent in the large group of cases studied. To what extent anemia, old age, and poor nutritional state contribute to this observation is difficult to evaluate accurately. In the absence of malignancy the latter three factors are also observed to influence the rate of healing of a wound. In view of the fact that the average age of the entire group of cases was 44 years and that 37 per cent of the patients were over 50 years of age, it seems probable that old age is a contributing factor of significance.

Howes and Harvey (16) have shown that any local situation which increases the exudative reaction in a wound will result in delayed healing. Trauma, devitalized tissue, blood clots, excessive amount of suture material as well as infection contribute to the delayed onset of fibroplasia because of the exudative reaction which occurs. In some instances of severe necrosing infection in the abdominal wound, the presence of a large slough of fascia will prevent healing until it has separated and been removed. Furthermore, the resulting defect in the fascia will prevent the wound from becoming as strong as it should be when it ultimately heals. Even if disruption does not occur through such a wound, the possibility of a subsequent hernia is not remote. If an infection of a wound is complicated by a fecal fistula, especially from the upper small intestine, the digestive secretions will have a detrimental effect on tissue repair. The presence of infection frequently renders the tissues so friable that any type of suture material used will easily cut through when under very little tension.

Strain on the healing wound. The presence of postoperative complications which result in increased intra-abdominal pressure has been emphasized as an important factor by Glasser, Milbert, and others. The constant pressure from distention and the sudden force from coughing, vomiting, retching, and hiccoughing, undoubtedly play an important rôle in disruption. Crying in infants puts a tremendous strain on the wound. When delirious or unruly patients get out of bed shortly after operation, they are likely to put an undue strain on the incision. Attempts to restrain such patients may result in an equally severe strain on their wounds if they thrash about. In coming out from anesthesia some patients are difficult to control. Two instances of audible breaking of the suture under such circumstances have been reported by Ries, and others have felt that the separation of the fascia in some cases undoubtedly dated back to this particular time.

The use of an abdominal binder has not been universally accepted as a method of relieving the tension which may be exerted on a wound during convalescence. The disadvantage of limitation of respiratory movements has been claimed by some to overcome any advantage that it might have in preventing strain on the wound. Most surgeons, however, feel that the use of a binder is a justifiable precaution either as a routine or in selected cases.

Additional support may be obtained by using adhesive tape over the dressings in one

way or another. A favorable method of holding the dressings in place and giving some support to the wound is the use of wide pieces of adhesive in which a number of small hooks are fastened. When the adhesive is put on the skin on either side of the wound one can then use a cord to lace up the hooks on either side. This merely imitates the principle used in the old fashioned corset. It gives excellent support, can be easily adjusted, and makes the wound readily accessible for changing of dressings. A similar method employing the "zipper" principle has been given more attention by the lay press than by the medical profession.

Anatomical aspects of the abdominal wall. The upper abdomen is most frequently approached through a rectus incision. Because of the preponderance of transverse fibers in the posterior sheath of the rectus it is frequently found that sutures of any type may easily pull through this layer, as pointed out by White. This is especially true when the patient has a very thin posterior sheath or when the patient takes a poor inhalation anesthesia. When there is inadequate anesthesia this layer may be torn to shreds before the closure is completed. The importance of a "difficult sew-up" is stressed by Grace. Koster and Kasman believe that the low incidence observed in their series was due to some extent to the use of spinal anesthesia which permitted a more complete degree of relaxation during the closure of the wound. The inherent weakness of the posterior sheath and the prevalent use of plain catgut, which lasts only 5 to 6 days under any conditions, for closure of this layer, are undoubtedly factors which are responsible for the frequency of disruption in the upper abdomen in the American cases.

When sutures are placed close together in the anterior sheath at the same distance from the edge of the incision it has been observed by White and Ries that the fascia may become so weakened by the multiple perforations that it will tear longitudinally, similar to the way postage stamps may be torn apart.

Irrespective of anatomical considerations the McBurney incision appears to offer the safest approach to the right lower quadrant from the statistical standpoint. Disruptions following this incision have been mentioned only by Maes, Boyce, and McFetridge and by Sokolov.

Omentum. It has been asserted by Freeman that the omentum is an important factor in the mechanism of disruption. He pointed out that the omentum forced itself through defects in the peritoneum as a result of inadequate closure. The swelling of the omentum incarcerated in the opening through the peritoneum was compared to an expanding wedge which progressed and prevented proper union of tissues. When some precipitating factor occurred such as vomiting or distention then disruption was likely to develop. The "omental wedge" theory of disruption has been somewhat more broadly applied than was originally intended.

In considering the rôle of the omentum in disruption it appears to be more protective than causative. It is rather fortunate that the omentum does plug up small defects in the peritoneum. If separation of the fascia occurs, the omentum will protect the bowel from the raw wound edges in most instances and thus prevent adhesions and possible obstruction. The omentum undoubtedly acts to some extent also as a mechanical restraint to prolapse of small intestine, whenever a defect in the abdominal wall occurs, similar to the action of a rubber "shoe" which is commonly employed in defective tire casings to prevent prolapse or injury of the inflated inner tube. Furthermore, the protective action of the omentum is such that in numerous instances of separation of the fascia the surgeon does not even suspect that anything unusual has occurred in the wound until the patient returns several weeks or months after discharge from the hospital with a large ventral hernia.

Factors attributable to the suture. Nature of the suture material. Disruptions have been found to occur regardless of whether wire, linen, silk, silkworm, or catgut is used. On the other hand, Baldwin and Kennedy claim complete immunity to the complication of disruption, which they attribute to their respective technique. The former uses a chromic catgut layer suture reinforced by tension sutures which are left in place 14 days. The lat-

ter depends entirely on through-and-through tension sutures without any layer suture. Reid has had an excellent record in a limited series of cases in which he used silver wire to close the abdomen of patients whom he considered potential candidates for disruption. The same technique in the hands of others has not been without mishap, as will be shown in a publication at a later date.

The advocates of the silk technique as well as many others have a feeling that silk is less likely to result in disruption than catgut. It is unfortunate that no comprehensive and comparable statistics are available on this point. The majority of the cases (275) reported by Sokolov were following the use of silk, but it is customary in Europe to use this material much more frequently than catgut. Linen offers no guarantee against disruption as illustrated by 4 cases in our series. In general it may be said that when non-absorbable material is used the factors influencing disruption are primarily referable to the surgeon and his technique and the ability of the patient's tissues to hold the suture material in the face of any strain on the wound from postoperative complications or conduct until adequate healing occurs. Inherent qualities of the suture material do not enter into the problem to the extent which occurs in absorbable material.

Catgut is the suture material commonly used in America for wound closure. Most surgeons use a chromicized catgut of the 20-day variety. The size frequently used is No. 2 or No. 1 although the No. 0 size is coming into wider use as a result of the work of Howes and Harvey, in which they reported that this size has adequate holding power in the tissues, and because of its smaller size causes less reaction in the tissues. The continuous suture is the most popular method, although for smaller sizes the interrupted technique is recommended. Tension sutures may be a routine with some surgeons, while others employ them in selected cases. A few do not use tension sutures at all. Occasionally plain catgut is used for a fascial layer. As this is not expected to last longer than 5 to 6 days, its use for fascia does not appear to have any logical justification. So called 20-day chromic catgut is supposed to maintain its tensile strength for approximately the period of time its label indicates when it is used in perfectly aseptic wounds. However, the observations which are subsequently described would tend to justify a suspicion that some brands of 20-day chromic catgut in certain sizes do not last nearly this long. Some companies use the term medium hard chromic to designate their product which is comparable to the 20-day catgut of other manufacturers. A large number of factors, however, appear to alter the rapidity of loss of tensile strength of chromic catgut of either the 20- or 40-day variety.

Mechanical damage. The injury to a continuous catgut suture in the anterior sheath by the cutting action of a tightly tied tension suture has been mentioned. It is not unusual to see a surgeon or his assistant tighten up a continuous suture by grasping it with a needle holder or hemostat. This will result in local damage to the catgut which may not only weaken its immediate tensile strength, but also render the catgut more vulnerable to the digestive action of the tissues at the point of local damage.

There are two points about the use of a "boilable" catgut which may alter its tensile strength if the operating room nurse does not handle it properly. When this type of catgut is removed from the tube, it is very brittle and unpliable. If the nurse endeavors to straighten out such a strand before it is made pliable by exposure to moisture there is likely to be some degree of fracturing at the points where it has been bent for insertion in the tube. Also if the nurse is in a hurry to render a "boilable" catgut pliable she may immerse it in very hot water. This procedure results in a marked decrease in the immediate tensile strength although its ultimate effect on the rapidity of absorption is not definitely known. When one considers the usual explosive response on the part of the surgeon to any delay encountered during an operation, it is not difficult to understand why a timid nurse may sometimes resort to this method of conditioning boilable catgut.

Imperfections. Kraissl has made some very important observations on "intrinsic factors" which result in loss of tensile strength. He

has found foreign body inclusions in practically all brands of catgut. These may be seen on close inspection and under the microscope. The nature of these inclusions has not been ascertained. He has also found flaws in some brands of catgut which appeared to be due to splicing of the catgut and also to the bending of brittle boilable catgut in the narrow glass tubes. He felt that these imperfections appreciably altered the rapidity of loss of tensile strength as determined by his digestion tests *in vitro*.

Rapid digestion. Kraissl has also shown that allergic reaction to catgut protein and sensitivity to chemicals used in processing chromic catgut may be factors responsible for more rapid digestion of catgut in some patients. In a study conducted on 19 patients surviving disruption at the Presbyterian Hospital of New York, he found that 12 were sensitive to catgut or chromic acid, or both. There were 4 patients of the 19 who gave a history which justified their classification as "allergic patients." All 4 of these gave a positive reaction to catgut protein or chromic acid. A large number of other patients were also tested for sensitivity. The results varied according to whether the patient had had a previous operation or to whether the patient had a constitution which on the basis of other evidence would justify the classification of allergia. The lowest incidence was 12 per cent in the group in which patients had not previously had an operation or were not otherwise allergic. Previously operated upon patients who were allergic showed an incidence of 37 per cent of catgut or chromic acid sensitivity.

The presence of infection has been clearly shown to hasten the disintegration of catgut. Howes and Harvey found that the chromic catgut of one manufacturer showed complete loss of tensile strength within 6 days, regardless of size or whether it was the 20- or 40-day variety. Infection of a wound is easily ascertained when suppuration is present. In some apparently clean wounds the presence of infection may be overlooked, especially when it is of the low grade or non-suppurative type. The rapid digestion of 20-day catgut in apparently clean disrupted wounds, which has frequently been observed by many surgeons, may be attributed in numerous instances to the presence of some degree of infection which was not associated with perceptible suppuration. A suppurative or non-suppurative infection may be localized to a small focus in a wound. If it occurs anywhere along the course of a continuous suture, the continuity of the catgut is lost at that point from rapid digestion. A disruptive force could then easily cause the rest of the continuous suture to pull loose from the fascia with subsequent separation. An obvious infection of the wound was noted in 22 per cent of the cases of disruption on which data pertaining to the condition of the wound was given. It is probable that many cases escaped this classification because of the absence of gross suppuration and the failure to make careful bacteriological studies.

A CLINICAL TEST OF THE DURATION OF TENSILE STRENGTH OF CATGUT

The "seton test." In an endeavor to obtain some information on the behavior of chromic catgut embedded in human tissues a number of tests were carried out on patients subjected to laparotomy. After the usual routine closure of the peritoneum, posterior sheath, and the anterior sheath an interrupted catgut suture was placed in the anterior sheath at one or both ends of the incision. One end of the suture was brought out through a needle puncture in the skin away from the line of the incision, while the other end was cut off near the knot. The free end lying on the skin could then be tested from time to time to determine when digestion had sufficiently weakened it to permit its being lifted out of the wound with a slight amount of tension. The day on which these strands could be removed was recorded. In this manner it was possible to obtain some very interesting data on the duration of tensile strength of so called 20- and 40-day chromicized catgut of different sizes from several manufacturers.

In most of the tests the chromic catgut seton appeared to be digested in the depths of the wound to a greater extent than at the point where it came through the skin. When tension was applied, most of the catgut setons broke deep in the wound somewhere near the knot. The extracted catgut showed evi-

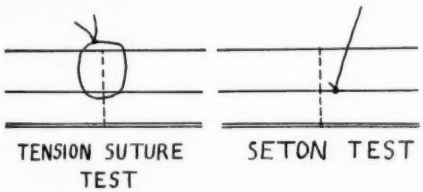

Fig. 1. Diagram to show method of carrying out the clinical tests in laparotomy wounds.

dence of varying degrees of digestion, fraying, and fragmentation between the points of penetration of skin and of rupture. In a few cases the continuity of the catgut was abruptly terminated at the point where it passed through the skin.

The tension suture test. In addition to the seton tests a similar number of observations were made by putting the catgut in the wound in the same manner one usually employs silkworm tension sutures. The tension suture tests were carried out in wounds which were adequately reinforced by other suture material so that the catgut tension suture was not depended upon for any holding power. It was observed that the time at which the tension sutures could be lifted out of the wound corresponded rather closely with observations made by the seton test as far as chromic catgut was concerned. (See Figure 1 for diagram of tests.)

The plain catgut of several companies was found to last 5 to 6 days under the conditions of the tension suture tests regardless of size or whether it was boilable or non-boilable. Plain catgut subjected to the seton test could easily be lifted out of the wound in 2 to 3 days. It was usually observed that the catgut had become untied in the fascia rather than digested in the tissues. Apparently plain catgut is acted upon by the tissues in such a way that any knot however carefully tied will tend to loosen up in a couple of days so that the slightest tension will permit it to untie.

A summary of the average duration of the tensile strength of the 20- and 40-day chromic catgut of 4 manufacturers of heat sterilized catgut is given in tabular form in Figure 2. The summary is based upon observations of over 300 different strands of catgut. The average represented by the black column represented 5–15 individual tests. Cases in which suppuration of the wound developed because of the nature of the operative procedure, such as the removal of a gangrenous ruptured appendix, were not included in the tabulation. In the limited observations on the behavior of catgut in the presence of suppuration it was observed that loss of tensile strength occurred 3 to 6 days sooner than was observed in clean wounds. In 5 cases in which the No. 0 40-day chromic of company A was tested in the presence of suppuration the average was 15 days. The observations on the 20-day catgut showed, in most instances, a more rapid loss of strength than in the case of the 40-day catgut of the same size and manufacturer. The size of the catgut appeared to make a difference in some instances, the larger lasting longer than the smaller for some brands, while just the opposite was observed in other brands.

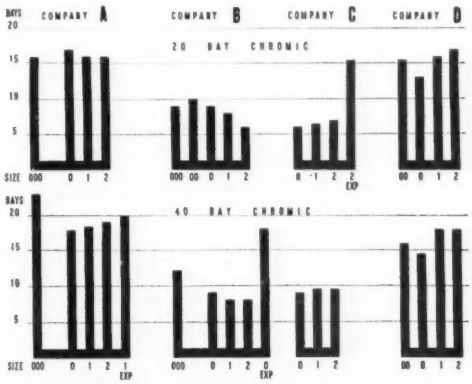

Fig. 2. Duration of tensile strength of chromic catgut as determined by clinical tests in clean laparotomy wounds.

EXP. Designates experimental chromic catgut put up by the several companies. The experimental product of Company C is expected to be modified by a slightly shorter period of chromicizing before it is available as a standard product.

Company A catgut was non-boilable. Most of the tests made with Company B catgut were with the boilable variety. Limited observations of the non-boilable chromic catgut of this company showed relatively little difference in the No. 1 and 2 size as compared with the boilable material. The No. 0 size of 20- and 40-day chromic of the non-boilable type, however, was found to last approximately 15 days as compared with the 9 days observed for the boilable. The experimental catgut of this company was non-boilable. Company C catgut was non-boilable except for the experimental product which was boilable. Company D catgut was non-boilable as far as these tests were concerned.

Variations were observed in different brands of comparable size and processing. It was also observed that there was considerable difference in the rapidity of digestion of identical catgut in different patients.

The average duration of tensile strength was often found to be quite a few days longer than the earliest day on which the catgut could be removed, because of the individual variation.

The longest period any test lasted was 31 days. This was with a No. 000 40-day catgut. In this instance the opening in the skin through which the seton was removed, was so small and free from irritation that it was difficult to identify this point after removal.

Regardless of what interpretation is made of the value of the test in anticipating the behavior of catgut used as a suture material for closing abdominal wounds, it did appear that some brands of the catgut were digested rather rapidly under the conditions of the test. Some brands did not last as long as it takes a wound to reach its maximum strength from healing, which Howes, Sooy, and Harvey (17) have found to be 10 to 14 days. Under adverse circumstances the period of wound healing would be longer than this.

Tests were also made on experimental chromic catgut prepared by several companies. In one instance it represented a chromic catgut prepared by a new process which the company expected to bring out as a standard product with some slight modifications. In two other instances the experimental product was prepared by the same process as the standard product but subjected to a longer period of chromicizing. That of Company A did not appear to increase the duration of tensile strength as determined by the clinical tests more than a day and a half on the average. The experimental product of Company B gave a very gratifying improvement over the standard product.

In considering the use of a catgut which is highly resistant to digestion, it is not overlooked that this type of catgut might result in extrusion of the suture or knots at a late date after operation. This phenomenon is observed after the use of non-absorbable material in the presence of some degree of infection. Even in clean cases catgut of the 20-day variety may extrude as late as a month or more after operation, especially if it is near the skin. It is probable that the size of the catgut may be a factor of some importance in this regard. If increased resistance to digestion can be gained only by increasing the incidence of extrusion of suture material at a late date, it is logical that one should resort to smaller sizes to avoid this complication.

EVALUATION OF STUDY

The data on the tests conducted in the presence of suppurative infection is probably an accurate index of the behavior of catgut under such circumstances. The observation that all brands of 40-day chromic catgut do not undergo complete loss of tensile strength in 6 days in the presence of suppuration, as noted with the product tested by Howes and Harvey (15), is interesting.

It is rather difficult to evaluate accurately the results of these clinical tests conducted on clean laparotomy wounds. The marked discrepancy between the observations made here on apparently clean wounds and the experimental observations of Howes would lead one to feel that this test probably does not indicate the behavior of catgut under strictly aseptic conditions in the wound of the patient or the experimental animal. It is probable that the more rapid digestion under the conditions of the seton test may be attributed to bacterial contamination from the skin which extends along the course of the seton. On the other hand the observation that most of the catgut setons broke off deep in the wound rather than at the skin would suggest the possibility that bacterial activity *per se* was not the entire explanation. Also there was no gross sign of infection of the wound about the seton. One would expect that a greater degree of bacterial contamination would be found at or near the skin rather than in the depths of the wound. The tests on the duration of tensile strength of catgut reported by Howes were conducted in the wall of the stomach of the experimental animal. This was performed by inserting a strand of catgut under the serosa of the stomach and removing it at varying periods of time to determine the tensile strength. The tensile strength of 20-day

catgut was found to decrease with striking regularity from a maximum at the time of operation to complete loss of strength at about the twentieth day. On the tenth day the tensile strength was practically one-half of what it was originally. Whether or not the digestion of catgut takes place at the same rate in stomach wall and in fascia and muscle of the abdominal wall is not definitely settled. Limited experimental observations on catgut embedded in fascia and muscle under strictly aseptic conditions tend to support the view that the catgut is digested under these circumstances much more rapidly than in the stomach wall. The results of these experiments will be reported later.

If the rapid digestion observed in these clinical tests conducted on apparently clean wounds is assumed to be due to the action of bacterial contamination which is not sufficient, however, to produce suppuration in these clean wounds, there are a number of situations in routine clinical surgery which are comparable to the conditions in which the test is carried out.

In routine abdominal surgery it is customary to classify the cases as clean, contaminated, or infected. This depends on the operative procedure or the pathology found. Where one draws the line between clean cases and contaminated cases varies somewhat with the surgeon. Whenever a structure which harbors bacteria is cut across there is a theoretical possibility that this may contaminate the wound. In instances where the surgeon is able to control any contamination completely as in the removal of an appendix during a quiescent period the case may be classified as clean. The incidence of obvious infection of the wound in contaminated cases is appreciable. It is not at all unlikely that many contaminated cases develop a degree of low grade infection at some point in the wound, which does not ultimately lead to suppuration. It is probable that these clinical tests may be an index to the expected behavior of catgut in wounds which are the seat of a low grade or non-suppurative infection. The presence of even a small focus of infection anywhere along the course of a continuous catgut suture can be expected to result in as rapid digestion of the catgut at that point as is observed in the seton test and tension suture test.

It has been frequently observed by many surgeons that there may be a considerable amount of digestion of 20 day chromic catgut in apparently clean wounds which disrupt within a week of the operation. In some instances no trace of catgut was found. It is not improbable that many of these apparently clean cases had some contamination at the time of operation and that the presence of a low grade or non-suppurative infection was responsible for the early digestion of the catgut. Meleney and Howes have obtained positive cultures from apparently clean disrupted wounds, in which the catgut was markedly digested. But they have also obtained sterile cultures from some wounds of this kind. It is rather interesting to compare the average day of disruption of 19 of the apparently clean cases, in which 20-day chromic catgut of one manufacturer was used, with the results of the clinical test for the same catgut. The average time of disruption for this group was 7.8 days and the average for the test was 6 days. Considering the fact that separation of the fascia frequently occurs a day or more before the disruption is recognized at the surface of the skin, it would appear that the clinical test coincided closely with the time of separation of the fascia.

There are some features about the use of silkworm tension sutures which deserve analysis from the point of view of possible extension of bacterial contamination from the skin to the depths of the wound. Regardless of how the tension sutures are put in it is reasonable to assume that in some instances one or more may come in close contact with the continuous chromic catgut used for approximating the fascia. Even if the tension suture does not result in mechanical damage to the catgut at that point, there is the added possibility that some bacterial contamination extending from the skin along the tract may be introduced at one or more points in the course of the continuous suture. This situation does not appear to differ appreciably from the conditions obtaining in the seton test. The rapidity of digestion of a continuous chromic catgut at

the point where it is in contact with a tension suture should not be expected to differ from that observed in the clinical test for that particular size or brand of catgut. It is difficult to ascertain how frequently tension sutures come in contact with a continuous suture in the fascia; nevertheless, this should be an additional point in favor of using interrupted catgut as recommended by Howes and Harvey rather than the usual continuous technique when tension sutures are employed.

The disadvantage of using a continuous chromic catgut suture for closing the fascia when drainage of intraperitoneal suppuration is carried out through the same wound has been mentioned previously. When a drain is used as a precautionary measure which is customary in cholecystectomy the use of a continuous catgut suture also warrants analysis. The presence of the drain may permit bacterial contamination from the skin to extend into the depths of the wound. This may result in as rapid digestion of the catgut which is tied above and below the drain as is observed in the clinical test. If the ends of the continuous suture which are tied adjacent to the drain become rapidly digested, then the rest of the suture should not be expected to hold the wound securely in the presence of any strain which might be put upon it as the result of postoperative complications or the patient's conduct. It seems appropriate again to suggest the use of interrupted sutures under such circumstances, at least a few above and below the drain, or a stab incision for drainage.

SUMMARY

1. A review of 1,294 cases of abdominal wound disruption has been made, including 36 cases from the University of Chicago Surgical Clinic. An analysis of the data on this large group has shown the following outstanding points:

2. The average age was 44 years.

3. There were 57 per cent males and 43 per cent females.

4. The primary disease necessitating operation was malignancy, 25 per cent; biliary tract disease, 12 per cent; appendicitis, 6 per cent; gastric or duodenal ulcer, 15 per cent; and gynecological conditions, 18 per cent.

5. The average time before disruption was 8.3 days.

6. The mortality was 35 per cent.

7. The factors influencing disruption have been discussed from the standpoints of the surgeon and his technique, of the patient, and of the suture material.

8. Factors attributable to the surgeon included faulty knot tying, the use of nonpliable catgut, of too much catgut and of a continuous catgut suture in the presence of drains or tension sutures.

9. Factors attributable to the patient included delayed wound healing, undue strain on the healing wound from postoperative complications or conduct, and inherent weakness of the posterior sheath.

10. Factors attributable to the suture material included mechanical damage to the catgut from instruments and soaking in very hot water, imperfections in the catgut, and rapid digestion as a result of sensitivity to catgut protein or chromic acid, and of infection.

11. A clinical test for the duration of tensile strength of catgut has been described as the "seton test" and the "tension suture test." When the test was conducted on clean wounds it was found that some brands of chromic catgut were digested in 6 to 10 days, while other brands lasted 15 to 20 days. The 40-day chromic usually lasted a few days longer than the 20-day chromic of the same brand. Plain catgut of different brands lasted 5 to 6 days by the tension suture test, but it was found that when plain catgut was used for the seton test it usually became untied in the tissues and could be lifted out in 2 to 3 days. The presence of some bacterial contamination which contributed to the rapid digestion could not be excluded as a possible factor of importance, although no perceptible suppuration was observed about the catgut.

CONCLUSIONS

As a result of the study of 1,262 cases of abdominal wound disruption it appears that a large number of factors may enter into the etiology of this condition. When absorbable suture material is used the rapidity of digestion of the approximating suture should be considered a factor of significance. In the

light of observations made on the duration of tensile strength of chromic catgut under conditions obtaining in the "seton test" and "tension suture test" it appears that:

1. Some brands of chromic catgut may be rapidly digested in the absence of perceptible suppuration, although the presence of some degree of low grade or non-suppurative infection cannot be excluded.

2. The rapid digestion of 20-day chromic catgut, which has been frequently observed in apparently clean disrupted wounds, can be attributed at least in some of the cases to the presence of a low grade non-suppurative infection.

3. The use of a drain or tension sutures in a wound closed with continuous chromic catgut is hazardous to the continuity of the suture.

4. The difficulties which may have been blamed on the use of so called 20-day chromic catgut can be attributed to some extent to the way in which the surgeon used the catgut as well as to the use of a poorly resistant chromic catgut.

5. There is a definite place in surgery for an absorbable suture material which can be depended upon to maintain its tensile strength under the conditions of the clinical tests described for at least 15 to 20 days. The 40-day chromic catgut of two reliable manufacturers approaches these specifications more closely than the 20-day chromic. It is hoped that two other companies will soon have a similar standard product.

6. In using a catgut which will resist absorption under these circumstances for 15 to 20 days, it must not be overlooked that under more favorable circumstances it might persist in the tissues for a much longer period of time and possibly result in extrusion of the undigested catgut in some instances. It is probable that this would be less likely to occur when smaller sizes of catgut are used.

7. Irrespective of the disadvantages mentioned the use of a highly resistant 40-day chromic catgut with these specifications would seem to be appropriate in the presence of contamination or suppuration, and in patients who might be classed as having a predilection for disruption.

ADDENDA.—During the past year and a half the 40-day chromic catgut which lasted by the clinical tests for 18 to 23 days has been used routinely for abdominal wound closure except by one member of the staff. Two disruptions reported in the survey occurred during the first 6 months of this period; however, only one additional disruption has occurred during the past year. In comparing this 18 month period with the two preceding 18 month periods, it is gratifying to find that the previous average incidence of 11 disruptions for both periods has been decreased to 3 for the past year and a half. It would not be altogether fair to give the highly resistant 40-day chromic catgut the entire credit for decreasing the occurrence of disruption, although it is obviously a considerable factor. Improvements in technique of some of the members of the staff have undoubtedly contributed to the fewer wound complications, such as the more prevalent use of interrupted instead of continuous sutures, chromic catgut for the peritoneum especially when this is closed along with the posterior rectus sheath, and the use of a separate stab wound for drainage instead of bringing the drain out through the main incision. The technique which appears to give the most reliable wound closure is the use of a zero size 40-day chromic as a continuous suture for the posterior rectus sheath and peritoneum and as interrupted sutures for the anterior rectus sheath or midline fascia. In addition, the wound is reinforced with silkworm tension sutures.

In using a highly resistant chromic catgut one occasionally encounters extrusion of suture material. It was interesting to find that during the 18 month period in which the highly resistant 40-day chromic was used routinely only 10 cases were found to develop a draining sinus with extrusion of a portion of the suture material. It was found that in general the smaller sizes of the 40-day chromic were less likely to lead to extrusion than the larger sizes. Considering that the 40-day chromic catgut was used in many cases in which the advocates of the silk technique would not dare to use non-absorbable material the incidence of 10 extrusions in 18 months is not a particularly poor record. If 10 cases of extrusion of catgut suture material is the price one must pay for 8 fewer disruptions than might have been expected in that period of time, it would not appear that the change from poorly resistant catgut to highly resistant catgut was without some merit. It is probable that the 40-day chromic was more resistant to tissue digestion than was necessary in a number of laparotomies. It is not necessarily recommended that such a catgut should constitute a routine for all wound closures; however, it should materially reduce the incidence of disruptions when used at least in midline or rectus incisions, especially in aged or cancerous patients, or when there is considerable contamination or infection encountered during operation.

Further studies are being carried out on other phases of the catgut problem including the digestion

time of catgut in acid pepsin solution, and the duration of catgut in the muscle and fascia of the experimental animal. These will be reported later.

An excellent survey of wound disruption following the use of catgut, silk, and silver wire will soon be published by Dr. Frank Glenn and Dr. S. W. Moore of New York. Their data on the incidence of disruption after the use of these three kinds of suture material is the most complete and comprehensive that is available in the literature.

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FRACTURES OF THE OS CALCIS

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THE incidence of fracture of the os calcis has been varyingly reported at other clinics as about 2 per cent of all hospital admissions for fractures. We have found a quite different proportion during the past 3½ years while caring for the injured during the construction work of the Boulder Dam. Undoubtedly fracture of the os calcis is one of the most common major fractures which is encountered in this type of work. Almost all injuries treated were the result of falls. We have found that the proportion of fractures of the os calcis to other major fractures is as follows:

Humerus	25	Tibia	85
Radius	63	Clavicle	16
Femur	21	Os calcis	43
Fibula	78		

The literature on the subject is amazingly barren with the exception of the brilliant work which has been done by Boehler and his associates. As will be discussed later under treatment, all sorts of methods have been employed in an attempt to reduce this most difficult of fractures. The end-results obtained have more or less proved the inefficiency of most methods. In Switzerland one-third total disability of the foot has been awarded uniformly. Magnuson, of the Illinois industrial commission, reported in 1923 that he had practically never seen fractured os calcis with less than 30 per cent disability and the disabilities ran up as high as 75 per cent in some cases. Kessler, in his book on accidental injuries, reports disability ratings which are approximately the same.

These fractures almost always occur in the varying phases of industrial work. Because of this they are most frequently seen by industrial surgeons and, for the same reason, by industrial commissions.

In this paper we have been most interested in presenting the end-results which we have obtained from a certain type of treatment. With a few modifications, this treatment is essentially that of Boehler. In presenting the end-results we have attempted to correlate them with our classification. This classification has worked most successfully, so much so that we feel that we can fairly well estimate the result and the disability rating from the type of fracture that we see in our first roentgenogram.

Classification—

I. Fractures of the body (Fig. 1).
II. Fractures of the tuberosity (Figs. 2 and 3).
    a. Splitting of the tuberosity with medial or lateral displacement.
    b. With upward displacement (Fig. 4).
III. Fractures into the calcaneocuboid joint (Fig. 5).
IV. Miscellaneous fractures.
    a. Fractures of the neck (Fig. 6).
    b. Avulsion fractures of the tuberosity.
    c. Isolated fractures of the sustentaculum.

I. Fractures of the body (Fig. 1). At the present time we have records of some 15 fractures of the os calcis in which there was a comminuted fracture involving the body of the bone. We had, at first, separated fractures of this kind into those involving both the subastragaloid and calcaneocuboid joints, those involving only one of the joints, and those apparently not involving either one. This made our classification needlessly complex for we found that the end-results were about the same. After all it is sometimes very difficult to tell just how much the joints are involved. The history in this type of fracture is always of a fall, such a fall varying from 5 feet on up. On examination, the patient does not appear to be suffering a great deal of pain unless he has other coincident fractures. There may be only a slight amount of swelling about the heel although occasionally the trauma about the subastragaloid joint may cause intense swell-

TABLE I.—COMMINUTED FRACTURES OF THE BODY OF THE OS CALCIS

Case Age	History	X-ray pictures	T. J. before reduction	Treatment	T. J. angle after reduction	Rating per cent	Coincidental fractures—remarks	Time off
O.M. 36	Fell 20 ft.	Comminuted fracture through body with involvement of both joints	10	Cast, no manipulation	0	12½		9½ mos.
F.H. 41	Fell 10 ft.	Same as above with upward displacement of tuberosity and widening	0	Boehler pins and clamp	22	15		7 mos.
C.J. 29	Fell 8 ft. landed on both heels	Longitudinal fracture into body without involvement of joints, left heel	30	Boehler pins	30	12½	Split through tuberosity of right os calcis	8 mos.
J.S. 34	Fell 10 ft.	Comminuted fracture into subastragaloid joint. Widening, splitting of medial tuberosity	15	Boehler pins and clamp to correct widening	5	40	Fracture caudal tip of astragalus. Fracture external malleolus	8 mos.
J.D. 49	Fell 8 ft. from moving truck	Comminuted fracture through body involving subastragaloid joint widening of body	13	Boehler pins and clamp to correct widening	13	10		7 mos.
O.M. 36	Fell 5 ft.	Comminuted fracture involving subastragaloid joint	8	Boehler pins and clamp to correct widening	21	10		7½ mos.
D.B. 44	Fell 20 ft. landed on both heels	Right comminuted fracture with involvement of both joints. Splitting forward of medial tuberosity		Boehler pins and clamp			This patient developed a low grade osteomyelitis in the pin holes of both heels. This has practically cleared up at the present time. A sequestrectomy was necessary on the left heel. The end-results will be fair on the right and poor on the left foot	
D.B.	Fell 20 ft. landed on both heels	Left comminuted fracture with involvement of both joints. Avulsion of tuberosity		Boehler pins and clamp. Pin placed anterior to the tendo achillis in the soft tissues				
F.P.		Comminuted fracture with involvement of the subastragaloid joint	12	No manipulation cast for 6 weeks	12	30		6½ mos.
N.B. 38	Fell 16 ft.	Comminuted fracture into both joints, with marked widening	0	Boehler pins clamp to correct widening	10	10	Accident 5 months ago, patient still off	6½ mos.
L.K. 38	Fell 18 ft.	Comminuted fracture into both joints, with marked widening	8	Boehler pins clamp to correct widening	26	15	Accident 7 months ago, patient still off	8½ mos.
E.M. 35	Fell 15 ft.	Comminuted fracture involving subastragaloid joint only. No widening	23	Boehler pins clamp to correct widening	30	18	Accident 3 months ago, patient still off	4½ mos.
W.C. 27	Fell 12 ft.	Comminuted fracture involving both joints	0	Boehler pins clamp to correct widening	26	5	Accident 2 months ago, patient still off	5½ mos.
F.W. 24	Fell 15 ft.	Comminuted fracture with involvement of subastragaloid joint only	—4	Boehler pin and clamp. Pin in front of tendon	26 (20)	3	Accident 1½ months ago, patient still off	6½ mos.
W.H. 37	Fell 25 ft.	Comminuted fracture with involvement of both joints and with marked swelling	0	Boehler technique with pin in front of tendon	30		Chip fracture 3rd lumbar vertebra. Compression fracture, 12th dorsal, accident 1 mo. ago, patient still off	

ing. The arch is flattened, the distance from the heel to the external malleolus being shortened as compared to the good foot. There is as a rule palpable and visible broadening of the heel with evidence of a bony mass driven up under the external malleolus. Pressure pain is strictly limited to the os calcis. Movement of the ankle joint is painless.

One must be on the lookout for coincidental fractures, particularly fractures of the vertebræ. These may be overshadowed by the fractured os calcis and are easily missed. In

badly fractured bones we routinely make an x-ray examination of the back and have been surprised on several occasions. Conversely, any patient who gives a history of a fall of 5 feet or more in which the heels or feet have been landed on should be subjected to x-ray examination for evidence of fractured os calcis despite the presence of other more severe fractures.

The mechanism of production of these fractures is essentially that the weight of the falling body is transmitted through the tibia to the astragalus which in turn is driven down into the os calcis. This explains the typical findings in comminuted fractures of the os calcis. Quoting from Boehler: "The lateral wall is broken off while on the medial side the posterior surface articulating with the astragalus is shorn off and is sometimes driven downward. In this manner the two fractures are produced in the sagittal plane (Fig. 1A). One involves the lateral wall of the bone, the other runs from the medial side of the bone obliquely forward. The medial fragment containing the sustentaculum tali usually remains in place while the middle portion of the bone and the lateral fragments are displaced laterally and appear as a hard bony mass below the external malleolus. Occasionally, the tuberosity of the os calcis is also divided into several longitudinal fragments. The os calcis appears, therefore, greatly broadened and shortened; while its width in the x-ray film is normally 30 to 35 millimeters it may reach 40 to 70 millimeters."

Boehler has repeatedly stressed the importance of an angle which he calls the tuber joint angle. As shown, this is the angle which exists between a line connecting the uppermost portion of the tuberosity and the highest point on the articular surface with a line connecting the same high point on the articular surface with the anterior process. Essentially this is merely an accurate manner of measuring the bony arch of the foot which is invariably flattened in fractures of the body. Normally the angle is 30 to 35 degrees whereas it may become flattened to 0 or less.

II. Fractures of the tuberosity (Figs. 2, 3, and 4). Almost all literature on fractures of the os calcis discusses mainly those of the body.

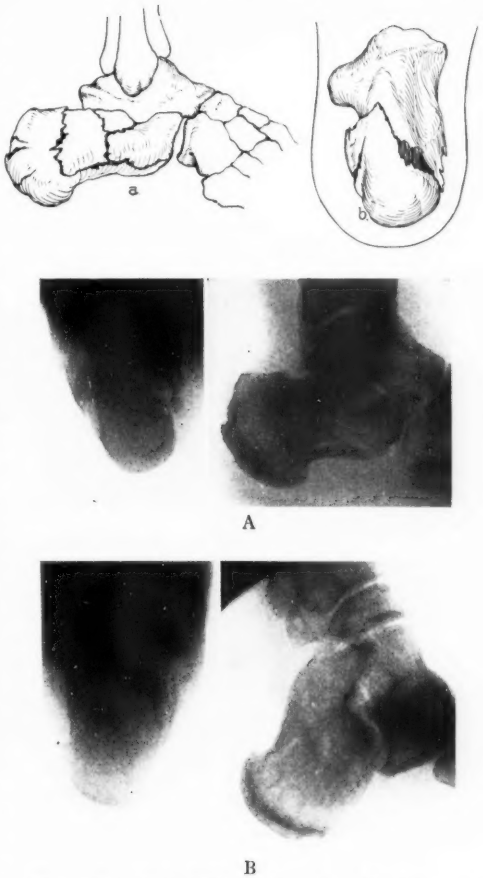


Fig. 1. Case N. B., Table I. Comminuted fracture of the body. a and b, Diagrams of fracture. A, Before reduction. Tuber joint angle equals 0. Boehler pins and clamp to correct widening. B, After reduction. Tuber joint equals 21 degrees. Body widening corrected. Ten per cent disability.

Key and Conwell state that fractures of the body comprise 90 per cent of fractures reported. We have not found that to be true.

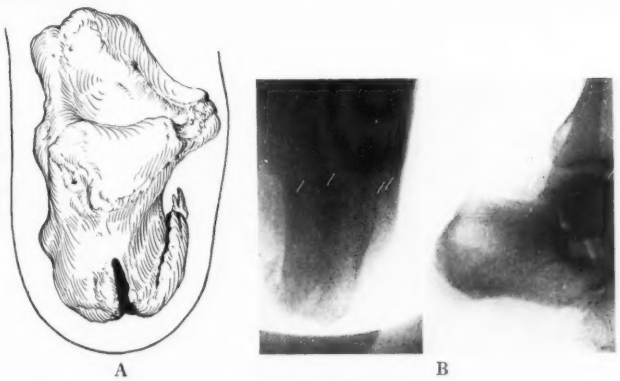
This type of fracture is easily missed as there is usually no visible or palpable disturbance of the bone except for tenderness directly over the heel. It is this type of fracture which is often found associated with more severe fractures, particularly of the back.

We have divided this type into subdivisions, namely: those consisting of longitudinal split-

TABLE II.—FRACTURES OF THE TUBEROSITY OF THE OS CALCIS

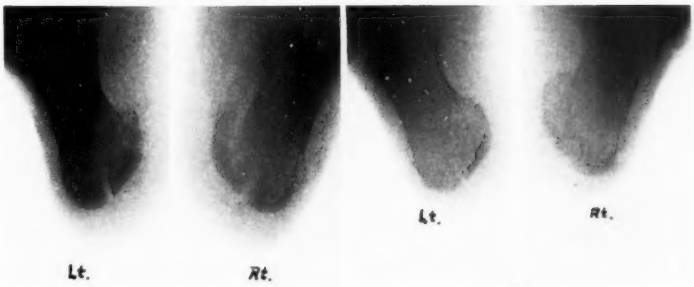
Case Age	History	X-ray pictures	Treatment	Rating per cent	Coincidental fractures—remarks	Time off
T.R. 19	Fell 30 ft. landing on heels, buttocks and left wrist	Left. Split through medial half with slight upward and marked medial displacement	Boehler clamp and cast for 3 months	2½	1. Compression fracture 12th dorsal vertebra 2. Chip fracture, 2nd and 3rd lumbar vertebræ 3. Colles's fracture, left wrist 4. Fracture tarsal scaphoid on right 5. Chip fracture anterior lip of tibia on left	6 mos.
T.R. 19	Fell 30 ft. landing on heels, buttocks and left wrist	Right. Same displacement	Same treatment	5	See above	6 mos.
A.P. 24	Fell 8 ft.	Chip fracture off medial inferior border of tuberosity	Cast, no manipulation	3	Complains of aching foot and of flatness of arch	6 mos.
J.E.	None obtained	Split through tuberosity with no displacement	Cast, no manipulation	Non-indust.		
J.B. 49	Fell 6 ft.	2 incomplete fractures through tuberosity	Cast, no manipulation	0	Compression fracture of 6th dorsal vertebra	5 mos. disability with heel
J.S. 33	Fell 6 ft.	Left fracture across medial side with some separation	Boehler clamp and cast	7½	Fracture 5th metatarsal right foot	3½ mos.
M.M. 37	Fell 15 ft.	Right, medial tuberosity split off with widening cast	Boehler clamp with cast	5		5½ mos.
M.M. 37	Fell 15 ft.	Left, anterior half of medial tuberosity displaced forward	Boehler clamp with cast	5		5½ mos.
L.O. 25	Fell 25 ft.	Chip fracture medial inferior side of tuberosity	Boehler clamp and cast	0		6 mos.
C.W.	Fell 5 ft.	Chip off of medial inferior surface without displacement	Cast, no manipulation	0		1½ mos.
H.H. 20	Struck by falling machinery	Incomplete fracture through tuberosity without displacement	Cast, no manipulation	0	Multiple fractures left ankle, back, and right heel	9 mos.
C.J. 29	Fell 8 ft.	Longitudinal split through tuberosity without displacement	Cast, no manipulation	17½	Foot shows no disability on final check	7 mos.
C.M. 26	Hit by rock	Chip fracture off the lateral process without displacement	Cast, no manipulation	0		5 mos.
C.H. 21	Fell 12 ft.	Split through medial process with slight forward displacement	No treatment, returned to light duty immediately	0		0
W.R. 18	Fell 25 ft.	Chip off lateral process with slight displacement	Cast, no manipulation		Accident 3 weeks ago, patient still off	
M.W. 21	Fell 15 ft.	Medial process displaced slightly medially and upward	Boehler clamp with anatomical reposition	0	Patient broke cast and fragment slipped out of position	4½ mos.
C.W. 26	Fell 30 ft. landing on reinforcing steel with left heel	Comminuted fracture of posterior upper half of tuberosity with marked upward displacement. With flattening of T. J. angle but without loss of arch (see Fig. 4)	Boehler technique and clamp. Pin placed through the soft tissue anterior to the tendo achilles	10	Accident occurred 8 months ago, patient still off	8 mos.

ting of the tuberosity with possible forward or lateral or medial displacement of the medial or lateral processes and those with marked upward displacement. The reason for this has been because of the marked difference in end-results and also because of the difference in the manner of incurrence of the two fractures. Simple splitting of the tuberosity is caused by a fall on the heel while in upward displacement of the posterior portion of the tuberosity the patient gives the history of falling on a small object which hits the posterior plantar surface of the heel. This would occur as in case C. W. (Fig. 4) in which the patient fell on a reinforcing steel rod. It is to be noted that in those instances where there is only a simple split of the heel the x-ray evidence of a fracture is obtained only in the dorsoplantar view and not in the anteroposterior or lateral views.



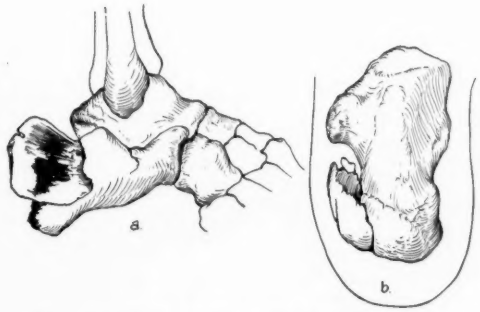
A B

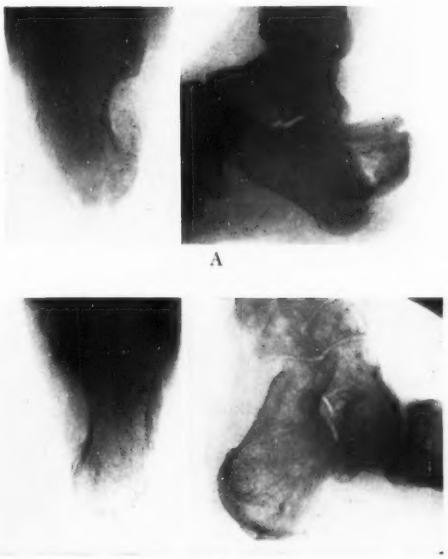
Fig. 2. Case L. O., Table II. Fracture of the tuberosity. A, Diagram of fracture. B, Roentgenogram of fracture before reduction showing longitudinal split with medial displacement seen only in dorso-plantar view. No disability.



A B

Fig. 3. Case T. R., Table II. Fracture of the tuberosity. A, Fractures of the tuberosities of both os calcis before reduction. Treatment, Boehler clamp. B, Fractures of the tuberosities of both os calcis after reduction. Widening completely corrected on the left and partially corrected on the right. End-result—"no disability."





A B

Fig. 4. Case C. W., Table II. Fracture of the tuberosity with upward displacement. a and b, Diagrams of fracture showing upward and medial displacement of fragment. A, Roentgenogram before reduction. Pin placed through the soft tissue anterior to the tendo achilles. B, Roentgenogram after reduction. Anatomical reposition. Ten per cent disability.

TABLE IIIA.—CHIP FRACTURES INTO THE CALCANEOCUBOID JOINT

Case Age	History	X-ray pictures	Treatment	Rating per cent	Coincidental fractures—remarks	Time off
D.	Struck by falling rock	Chip, inferior angle C. C. joint	Cast	0		
G.L. 28	Caught in rock slide	Fracture, inferior edge of C. C. joint with slight displacement	Cast	10	Compound fracture of fibula	7 mos.
G.W. 18	Struck foot against timber	Chip off medial side of C. C. joint	Cast	0		1 mo.
J.W. 26	Foot caught under falling cable socket	Chip into C. C. joint	Cast	0	Periosteal tear of adjoining tarsal bones	3 mos.
L.D. 24	Struck on foot by falling timber	Chip fracture off inferior edge of C. C. joint	Cast	0		4 mos.
L.W. 27	Fell 20 ft.	Chip fracture off of superior edge of C. C. joint	Cast	0		2 mos.
H.H. 20	Struck by falling machinery	Small comminuted fracture inferior edge of C. C. joint. Right heel	Cast	0	Multiple fractures of the back, left heel, left ankle and right foot	9 mos.
C.B. 30	Squeezed foot with cable	Chip fracture off superior edge of C. C. joint	Cast	0		2½ mos.
P.B. 32	Push cart caught right heel	Fracture line extends from the upper part of the C. C. joint posteriorly and upward into the subastragaloid joint	Cast	0		3½ mos.
R.C. 28	Rocks fell on foot	Chip fracture off the superior edge of the C. C. joint	Cast	0		1½ mos.

TABLE IIIB.—FRACTURES THROUGH THE NECK OF THE OS CALCIS

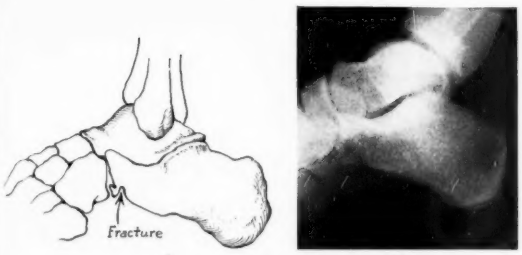
Case Age	History	X-ray pictures	Treatment	Rating per cent	Coincidental fractures—remarks	Time off
M.P. 26	Injured in football game	Fracture through the neck with no upward displacement	Cast	0		2 mos.

III. Fractures of the calcaneocuboid joint. Here again is a fracture which although noted in the various classifications is considered to be relatively rare. It is possible that it may be included by other authors in fractures of the body. We have classified it separately because of the fact that it is incurred in a different manner and secondly the end-results have been almost uniformly "no disability."

The history of these cases is invariably that the patient received a sharp blow over the calcaneocuboid region as by a falling object or that his foot was crushed as in a rockslide.

IV. Miscellaneous fractures. There are reports of isolated fractures of the sustentaculum tali and of avulsion fractures of the tuberosity. We have seen none of these and would refer you to the bibliography for detailed information. We have, however, seen one odd type of fracture which has not heretofore been reported, namely: case M. P. (Fig. 6). This patient received the fracture while playing football and does not recall the mechanism in which it was incurred. It was a simple fracture through the neck of the os calcis without displacement. A simple cast for 2 months apparently gave complete healing and the patient had no disability.

X-ray views. The ordinary anteroposterior and lateral views of the ankle are taken. The anterior view is not of much value in the diagnosis of os calcis fractures but serves to eliminate fractures of the astragalus and of the malleolus. In addition, we again stress the importance of the dorsal plantar view. As demonstrated in the x-rays of case L. O. (Fig. 2), no evidence of any fracture is seen in the lateral view but a definite split of the tuberosity is seen in the other view. In obtaining this view our technician has the patient lie on his stomach with the affected leg slightly flexed at the knee and supported by a sandbag. The x-ray film is placed against the sole of the heel and the x-ray tube is placed at an angle



A B

Fig. 5. Case H. H., Table IIIA. Fracture into the calcaneocuboid joint. A, Diagram showing chip fracture into the inferior border of the calcaneocuboid joint. B, Roentgenogram showing same fracture.

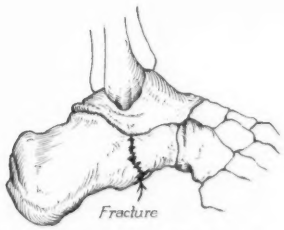


Fig. 6. Case M. P., Table IIIB. Fracture through the neck. No disability.

toward the film so that the cone is almost vertical to it.

We also stress the importance of frequent check up x-rays which are taken every month or 6 weeks when the cast is changed and after all casts are off. We have found several cases in which a slight flattening of the arch has occurred due to the patient walking on the foot too much after the third and last cast is off. A final check up is always taken before the patient is seen for a rating by the industrial commission.

TREATMENT

The astounding amount of disability incurred in fracture of the os calcis and the difficulty of satisfactory reduction has given rise to several methods of treatment, including Achilles tenotomy and pounding laterally on the bone to reduce widening, and immediate subastragaloid arthrodesis with chiseling away of the lateral mass which has become displaced up under the external malleolus, but to Boehler belongs the credit for an anatomical replacement of bone fragments and restoration of the normal angles and lines of stress in the foot in a relatively simple manner.

An outline of the method will aid in clarifying controversial ideas in regard to technique with minor points wherein we have changed from his original routine as wider experience with this method has so warranted. The original set up in its mechanics is correct, since end-results show an anatomical reposition of fragments with restoration of the normal arch of the foot and of length and proper narrowing of the body of the os calcis. In the first place, we believe in immediate reduction and contend that it is easier of accomplishment before soft tissue swelling has infiltrated and stiffened supporting ligaments of the joints. Most of these fractures have been reduced and placed in plaster casts within an hour from the time of sustaining injury.

After the spinal anesthesia is given, the foot and leg are scrubbed with green soap and painted with iodine and alcohol. Any swelling present is massaged upward beyond the malleolei. By a study of the x-ray film, the exact point in the os calcis is determined for insertion of the Boehler pin, and this is driven through from lateral to mesial sides and the stirrup attached. When the bone is so fragmented that the insertion of a pin into its substance would probably tear through, the pin is inserted instead in front of the tendo achilles, resting upon the tuberosity. In those cases in which this procedure is done, the resulting reduction is not quite so satisfactory anatomically due to some forward rotation of the tuberosity, and also the patients complain of some pain during the time that the pin is left incorporated in the cast. The point of insertion in the tibia is just proximal to the epiphyseal line, and here we are now using a Kirschner wire after having three times split the tibia using the Boehler pin. The leg is then placed in the Boehler frame, the spreader attached to the tibial wire made fast to the overhead bar and that of the os calcis to the turnscrew. The knee must be at a right angle to give maximum relaxation of the gastrocnemius. The first pull is directly downward to break up the impaction in the subastragaloid region before the body is lengthened, then downward as the resultant of the up and forward pulls, which lengthens the body of the

TABLE IV.—SUMMARY OF CASES REPORTED

Type of fracture	Cases	Per cent type	No. rated	Average rating per cent	Average time off
Comminuted fractures of the body	15	34.9	12	15.1	7 mos.
Fractures of the tuberosity with medial or lateral displacement	16				
Fractures of the tuberosity with upward displacement	1				
Total fractures of tuberosity	17	39.5	15	3.2	5.1 mos.
Fractures into the calcaneocuboid joint	10	23.2	10	1	3.7 mos.
Fractures through the neck	1	2.4	1	0	2 mos.
Total	43		38	4.29	5.32 mos.

os calcis and restores the normal tuber joint angle, thus restoring the long arch of the foot. The Boehler clamp is then placed with its pressure knobs on each side of the body of the os calcis and screw pressure made until the body is narrowed to normal or nearly so. The pressure need be for only a minute or two, as the fragments once reduced do not again displace with the foot and leg in the traction frame. An adhesive strip from the footsole to the overhead bar keeps the ankle in right angle position. X-ray pictures are then taken to check position, and, if found satisfactory, an unpadded posterior splint is placed from the level of the tibial tubercle to and including the toes, being wrapped with circular plaster bandages. When the plaster has set, the frame is removed, the tibial wire also, and the leg placed upon a Braun frame with a weight of 6 to 8 pounds attached to the heel pin.

With this apparatus in place, the patient remains in bed 4 to 4½ weeks during which time he is encouraged and in fact ordered to move the toes and the knee because of the belief that intermediate joints tend less to form adhesions if those proximal and distal can be moved, and our experience has borne this out even when fractures have involved joint surfaces. In those cases with primary swelling or in which there was sufficient crushing of soft tissues to expect swelling, we have split the cast in the midline anteriorly and there has been no constriction of blood supply. As the swelling recedes, which it seems to do more quickly when the circulation is supported by a cast, the spread edges of the cast are approximated and held with adhesive. In these cases we have not seen blebs forming on the skin as does occur after crushing injuries and regret that in our one case of maximum disability we were not then following this procedure, but had waited some 16 days for the original swelling to subside.

When the first cast is changed, the leg is again placed in the Boehler frame in the same position as when first applied. The cast is removed and the skin cleansed with benzine and alcohol. We have had no pressure sores from casts applied directly to the skin because great care is taken that they be smooth. The practice of placing dry gauze about the points of entrance and exit of the pin into the heel instead of balsam of Peru as originally advocated has given us dry healthy skin at these points. X-ray pictures are then taken to assure that the correct alinement has been unchanged and a new unpadded cast is now applied. When set, the leg is taken down and again placed upon the Braun frame. After 48 hours, the pin is removed from the heel and a walking stirrup attached to the cast. The patient may now be ambulatory and is encouraged to walk on the stirrup, if possible without crutches. The bone fragments are not displaced by so doing and it is a stimulus to callus formation.

In 4 weeks the cast is removed and the foot is manipulated to secure all joint motions. This practice of frequent change of casts has allowed the restoration of full joint motion in relatively short time: in most patients very little is ever lost. A third cast is applied with a walking-stirrup and remains on the foot for another month. When the last cast is removed, the patient must wear his shoe immediately and keep it on to support circula-

tion. He begins weight-bearing on the foot gradually, now using crutches for support, and in some cases it is a month or two before he is allowed to dispose of them entirely. In 6 to 8 months from injury he is returned to work. We feel that the long period of total temporary disability has insured a lesser partial permanent.

END-RESULTS

The estimates of our end-results we have considered to be fairly accurate and certainly impartial, inasmuch as they are made by the members of the Nevada or Arizona Industrial Commission.

An accurate estimate of disability for fractures of the os calcis alone is difficult, because some cases are complicated by other fractures of the same foot, and the pain factor cannot be definitely allocated to a specific bone. But the same conditions obtain in any series of cases, and these ratings, as awarded by the commissions, should thus be on a fair basis with those reported in such series.

We usually have our patients back on the job for two to four months before any attempt is made to rate him. In that way a truer picture of the end-result is obtained than if they were rated before returning to work. It is unfortunate that we cannot present more rated cases, but the reason for this is that the majority of our series of cases were injured during the last two years or after the Dam began to climb up into the air and accidents were mostly from falls.

Comminuted fractures of the body. Contrary to the reports of other authors, this particular fracture has not occurred so frequently in our series of cases. Some authors report this fracture as occurring in 90 per cent of cases. In our series it has occurred in only 34.9 per cent of the cases. This is, of course, the type of fracture which yields tremendous disabilities. Of the 15 cases of this type, we have 12 which have been rated, the average disability being 15.1 per cent and the ratings running from 3 to 40 per cent. Some of the cases are quite difficult to estimate, for example case J. S., Table I, who had a rating of 40 per cent total permanent disability of the affected foot. In addition to the fractured os calcis he also had fractures of the astragalus and of the external malleolus. He developed such tremendous tissue swelling and evidence of an impaired circulation that it was necessary to wait some 16 days before attempting any reduction. As will be noted the reduction was unsatisfactory at that time as the tuber joint angle was only 5 degrees after reduction.

On the average we keep these patients off work for 7 months. We have found that they almost always complain of pain in the subastragaloid joint at first. This is particularly noted when stepping on uneven ground when they first begin to walk and is always noted for some months after they begin to work. Those patients who have received large disabilities complain the most of this pain, but in most of the cases that have been under observation for a year or longer this pain either greatly subsides or disappears altogether. We have yet to do a subastragaloid arthrodesis for relief of this pain and all of the cases rated have been returned to their original jobs, which is after all the final criterion. Many writers have reported painful heel pads. We have not seen this persist over any period of time. In checking our reductions we have laid stress on the tuber joint angle as a method of measuring the degree of reduction. Unfortunately, the cases which have been most accurately reduced, as measured by the change in the tuber joint angle, have not been rated as yet, so the results can not now be recorded. Occasionally, however, a fracture which has not been properly reduced will get an excellent result. We can attribute this only to a minimum of joint involvement.

Fractures of the tuberosity. This type of fracture has occurred a little more frequently than any other and, although not as difficult to reduce, can still be very disabling if not properly reduced. The end-results here have been very satisfactory, only a few patients sustaining any final disability whatsoever. We have had some 16 fractures of the tuberosity in which there was only a longitudinal split with medial or lateral displacement. Eleven cases have been rated, the average disability running 3.25 per cent and the average time off being 5.15 months. Those few patients who have been estimated as having disabilities have complained primarily of tired aching feet

similar to the complaint of a patient with flat feet. In following up these patients we have stressed the use of arch supports and of exercises to strengthen the arches. We must mention here that the average time off for this and for the other types of fractures is not always accurate inasmuch as these patients often have other and more severe injuries which keep them off for a considerable length of time.

Chip fractures into the calcaneocuboid joint. As far as end-results go these fractures are relatively unimportant as the patients almost all have no complaints when returned to work. We believe that this type of fracture should always be considered when the patient gives a history of a blow or of a crushing injury involving the foot. Because of its relative rarity in all reports on fractures of the os calcis and with the frequency of its occurrence in our series we believe that it must be frequently missed. The average time off has been 3.7 months and in frequency we have seen it in 23.2 per cent of our cases. The disability has been zero in all except one case in which a 10 per cent total permanent disability of the foot was given.

CONCLUSIONS

1. Forty-three cases of fractures of the os calcis are presented.

2. The Boehler method of treatment with anatomical reposition of fragments gives the least disability of any accepted method of treatment with emphasis upon immediate reduction in all cases.

3. A simple classification of fractures of the os calcis is presented which gives a fairly accurate estimate of the amount of disability to be expected.

4. Chip fractures into the calcaneocuboid joint are demonstrated to be of common occurrence. One rare fracture entity is also presented, namely: simple fracture through the neck of the os calcis.

5. A revised estimate as to the relative proportion of the various fractures of the os calcis is demonstrated in our series.

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This work was done at the Six Companies Hospital, Boulder City, Nevada, and as staff members we acknowledge with thanks the kindness and co-operation of Dr R. O. Schofield, Chief Surgeon.

CLINICAL SURGERY

FROM THE KROMERIZ GENERAL PUBLIC HOSPITAL

ARTHROPLASTY IN ANKYLOSIS OF THE KNEE BY INTERPOSITION OF PATELLAR FLAPS

DR. J. ELGART, Kromeriz, Czechoslovakia

FOUR years ago I operated upon a patient for ankylosis of the knee and the technique used is the basis of the method here described. Unfortunately, however, the patient was suffering from a sarcoma of the condyles and rapid relapse necessitated amputation. From this experience it was plain that while the operation was not suitable in case relapse was imminent or in the presence of sarcoma or tuberculosis, it was indicated only in the presence of ankylosis of the knee of long standing. I have had no further experience with the operation, nevertheless I will describe the technique in the hope that someone will have an opportunity to try it.

For our purpose we may say that operation is indicated in two types of cases: (a) in femorotibial ankylosis where the patella is free or only fibrously fixed, as revealed by the roentgen ray—a favorable case; (b) in total destruction of the inner surface and synostosis of the three bones—a less favorable case.

I shall not enumerate the possible advantages of my method as against the interposition of fascia or fat; I wish only to emphasize that in my operation I use flaps of the patella with broad pedicles; the flaps should include at least a part of the cartilaginous surface which may be of use in the later transformation and adaptation of the nearthrosis.

Interposition of a posterior vertical frontal segment of the patella. After a U-shaped flap of skin has been turned back in an upward direction, we make two longitudinal incisions, one on either side of the patella, and also isolate the upper tendon and the lower ligament. We liberate the posterior surface of the kneecap which we then divide into two segments or laminæ, the saw being introduced from behind. The incision in the bone is enlarged by means of a scalpel which is introduced from in front, and cuts down through the inferior ligament. We then dislocate the back plate of the patella laterally and divide it into two longitudinal pedunculated flaps which are attached only to the inferior ligament. Next a lateral incision is made across the capsule of the joint so as to permit free access to the femorotibial synostosis. At both sides of its central fibrous mass (ligamenta cruciata), we pare off a section 1 to 1.5 centimeters thick and these sections form two clefts for the interposition of the two patellar flaps. These flaps may at some future time form a new condyle. The wound is closed with a hermetical suture.

For cases of posterior synostosis of the patella we would modify the operation by cutting off an anterior flap of patella which, after it is cut longitudinally, is interpolated. The liberated piece of the patella is finally fixed to the tibia. In this modification the anterior surface of the interposed patellar flaps forms the necessary fibrous and endothelial interior surface of the new joint. The pedicles of the patellar flaps—necessary at first to furnish bone nutrition—must later be separated subcutaneously (after 4 to 5 weeks) before movement of the knee can be started.

I anticipate that the new condyles undergo transformation because of the subsequent movement of the joint so that the remaining cartilage will probably spread across the whole inner surface of the bone. I admit that we can obtain the same result with the free transplantation of the patellar parts; on the other hand, a pedunculated flap always has a better chance to survive, especially when its innervation is at least partially preserved, for it is then not only a stimulant to the femur but materially aids in the functional transformation of the bone.

It is perhaps not necessary to emphasize the fact that for the future stability of the joint two neocondyles (two interposed patellar flaps) are better than a non-divided one.

Another form of operation with four fragments of the patella. A small segment of the patella is first separated horizontally at the top, then a similar one is separated at the bottom and an incision is made vertically down through the middle of the remaining portion. The resulting 4 segments re-

Chief Surgeon, Kromeriz General Public Hospital.

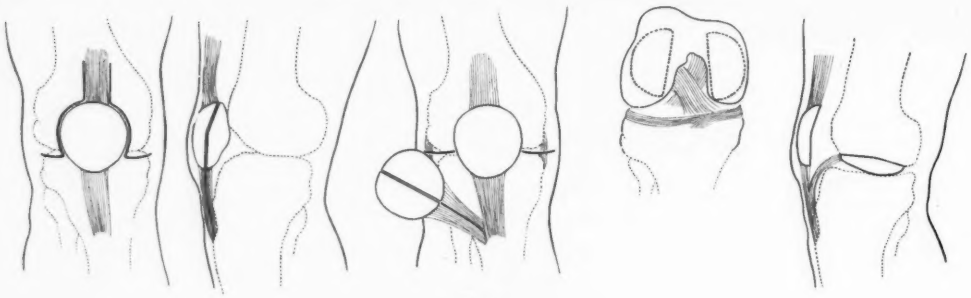


Fig. 1.

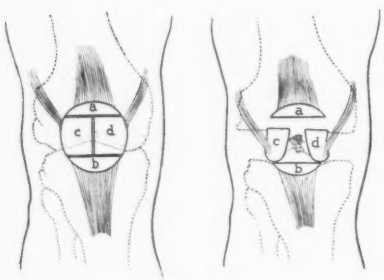


Fig. 2.

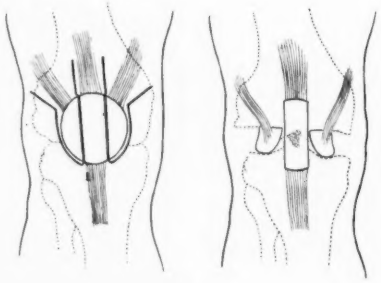


Fig. 3.

main connected to the surrounding soft tissue which is divided into 4 pedicles. Thus after liberation from the rear we have 4 bony flaps radially everted. The final steps of the operation are the same as in the preceding operation: we pare off two laminæ from the femorotibial synostosis on either side of the middle fibrous mass (ligamenta cruciata), and interpose therein the two lateral patellar flaps to form the condyles (*c* and *d*); the upper and the lower patellar segments are then sutured so that a new reduced patella results (*a* and *b*).

Operation with longitudinal separation of the patella into three parts. In this method we pare off vertically from each side of the patella a lateral segment so that the central portion becomes a reduced kneecap which is connected with the upper tendon and the lower ligament is left intact. By lateral incision and liberation of the segments from behind we obtain two pediculated lateral patellar flaps which are to be interposed in the space made by the removal of the two laminæ from the femorotibial synostosis. Technically, this method is perhaps the easiest one and most advantageous as the continuity of the extensor apparatus remains intact.

ADVANTAGES

All three procedures have evidently some advantages over fascial or fat transplantation. The flaps usually have some vestige of cartilage or at least a fibrous and endothelial surface from the bursæ, which enlarges later at the inner surface of the new joint. Even in case of absolute destruction of the cartilage we can help by the free interposition of particles of the rib cartilage between the separated bones. Innervation of the pedicles (for the future functional transformation) is a great advantage over the old methods.

Finally, it should be stated that in each method the strain of the extensor tendon must be carefully adjusted in length by folding if necessary.

NEGLECTED AND RECURRENT BASAL CELL EPITHELIOMAS OF THE FACE

HERBERT WILLY MEYER, M.D., F.A.C.S., New York, New York

WHEN one has occasion to perform an operation for an extensive basal cell carcinoma of the face and in so doing has to perform an extensive and often mutilating operation in an effort to cure the patient, it is only natural that the thought comes to mind of how this severe surgical procedure could have been avoided.

Of course, we all know that cancer is a disease in which no one single method will assure a good result in all instances. Yet we know well that basal cell epitheliomas of the face are seen early, can be diagnosed early, and do not metastasize to distant parts of the body. If treated radically and early, a cure should be effected.

But the entire lesion must be destroyed in the first procedure or else the tumor cell if still present will slowly grow and break through a beautiful superficial smooth scar and grow as wild as it did before or wilder. We must also realize that it can break forth and grow on the lateral aspects of the scar and just as well break through and grow underneath a scar where it is not visible or palpable until later. It may also mushroom out underneath normal looking skin from the margins of a normal looking scar and only become noticeable and palpable some time later.

Physicians and surgeons interested in and specializing in cancer therapy have often felt that it would be well if all cancer could be treated in cancer centers by trained cancer specialists.

It is perfectly true that the average early basal cell epithelioma can be cured if it is completely destroyed. Whether that be by properly dosed and efficiently given x-ray or radium, or if it is destroyed by the galvanocautery, electrocoagulation or by surgical excision makes no difference just so long as the lesion is thoroughly and completely destroyed or removed.

A basal cell lesion on the soft parts with underlying fat and muscle can be destroyed and cured more easily by the average trained man in x-ray or radium or by surgery than if the lesion overlies cartilage and bone. Experts can cure basal cell lesions overlying cartilage and bone with radium and x-ray but unfortunately recurrences appear only too often when these cases are treated by the average trained man. The lesion seems to heal only to recur and involve the underlying cartilage or bone and then x-ray or radium is used again in an effort to destroy the lesion. Now it must be used as an actual cautery in order to cure the cancer and a hole must be burned as with an actual cautery. Similarly, if a surgeon excises the cancer and does not take along the underlying cartilage or bone a recurrence will take place and necessitate a later, much more extensive and mutilating operation.

The average physicians using x-ray and radium must also learn to recognize those lesions which are ray resistant and if irradiation given in proper doses does not cure the lesion early then irradiation will surely not cure it later and the case should be referred on to the trained cancer surgeon specialist.

Similarly, if the average surgeon has operated on a basal cell cancer and a recurrence appears he should likewise not attempt a further small operation possibly under local anesthesia but should refer the patient on to the cancer surgeon specialist for a radical operation. This is the only way in which the patient can have a chance for a cure and for life.

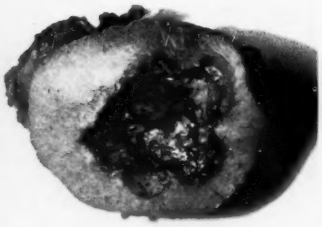
We have had four cases which clinically bring out some of the above mentioned points and we feel that it would be of interest to describe them.

CASE 1. J. C.,[1] aged 45 years. This man noticed a small, white patch on his right cheek about 1 inch below the margin of the lower eyelid. This was in 1929, 6 years ago. This little raised area broke open by itself. He immediately went to a physician. The physician advised treatment for an infection. It did not get well. X-ray treatment was started in July, 1929 by this physician. The lesion never healed completely for 6 years. It was apparently ray resistant and in spite of this, x-ray treatment was employed by the physician for more than 5 years. Early in 1935 it got rapidly worse and a lay co-worker in the business office of this patient finally referred him to us in May, 1935.

The lesion could have been easily removed or destroyed in 1929 when it was seen that x-ray did not cure it. As it was, the lesion now measured 6 by 4 centimeters and was adherent to the underlying portion of the superior maxilla, the lateral nasal process of the superior maxilla and to the floor of the orbit. It was also adherent to the zygomatic process of the malar bone. X-ray showed no clouding of the antrum (Fig. 1). It was decided, therefore, that only radical removal of the tumor with a safe margin of skin on all sides, and all of the adherent underlying bone, floor of orbit, outer wall of antrum, malar bone and nasal process

[1] Case presented before New York Surgical Society, April 22, 1936.

Fig. 1.



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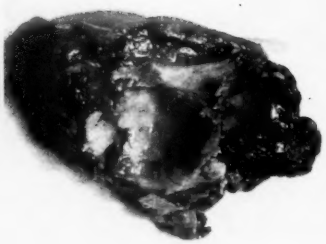

Fig. 3.

Fig. 1. Epithelioma of cheek adherent to underlying bone.

Fig. 2. Outer surface of specimen showing carbonized ulcer and section of malar bone, left upper corner.

Fig. 3. Inner view photograph of the specimen showing the floor of the orbit above, the inner surface of the antrum below, and a section of the malar bone to the left.

of the superior maxilla, might effect a cure. The patient was asked to give consent to exenteration of the orbit if it was found that the orbital contents were involved. This he did. The large resulting defect was to be closed by a pedicle tongue flap taken from the temporal and forehead region with the pedicle base in front of the ear and containing the temporal artery.

Operative procedure—May 25, 1936. A short incision was made along the anterior border of the right sternocleidomastoid muscle at the level of the hyoid bone. The external carotid artery was exposed. A double strand of heavy catgut was placed around the external carotid artery just above the emergence of the superior thyroid artery and brought out through the wound. The platysma was sutured with interrupted sutures and the skin with interrupted silk. A hemostat was placed on the catgut ready for an assistant to pull and angulate the artery to control bleeding during the resection of the tumor and then with relaxation and removal of the catgut have the full blood supply for healing of the plastic procedure. This is a principle taught and practiced by Dr. George H. Semken.

The entire ulcerated lesion was then cauterized and covered with gauze held in place by silk mattress sutures to prevent implantation of malignant cells into the raw, fresh wound. The lesion was then circumscribed with an electric cautery knife, staying at a wide margin from the edge of the tumor. It was deepened all the way to the bony landmarks exposing the floor of the orbit, the nasal process of

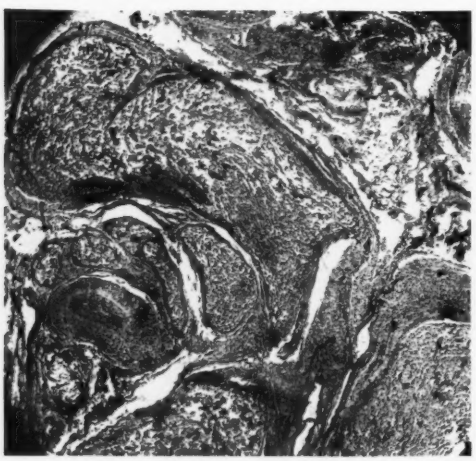

Fig. 4. Photomicrograph of tumor showing squamous cells with pearl formation.

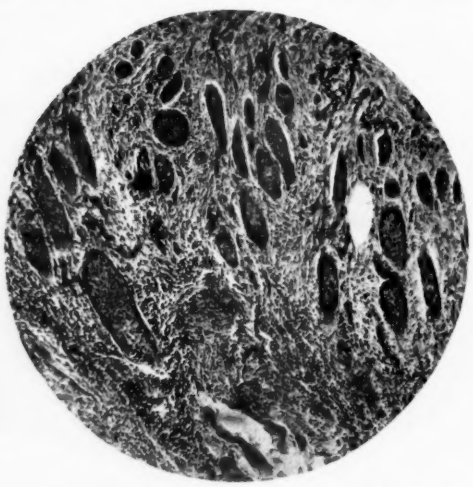

Fig. 5. Photomicrograph of tumor showing basal cells.

the superior maxilla mesially and the alveolar process below, and the superior maxilla and malar bone on the outer margin. Only a very narrow strip of the lower eyelid was saved and also of the upper lip. After exposure of all the bony landmarks the bones were divided with chisel cuts, beginning with the nasal process of the superior maxilla into the floor of the orbit. The orbital contents were found free of tumor but the tumor appeared adherent to the periosteum of the outer surface of the superior maxilla along the lower orbital margin. The malar bone was divided and the chisel cut prolonged into the orbit to meet the chisel cut from the nose. The superior maxilla of the outer wall of the antrum was divided from the nose outward parallel with the alveolar margin along the floor of the antrum. From the outer margin of the antrum wall a chisel cut was made upward to meet the division of the malar bone down to the superior maxilla. These bone sections freed the tumor and allowed it to be removed in one mass (Figs. 2 and 3). The skin edges previously cut with the cautery knife were freshened with a scalpel. The floor of the wound was lightly cauterized. A strip from the anterior border of the temporal muscle was cut down to the coronoid process of the inferior maxilla. This coronoid process was chiseled off, thereby forming a sling which was placed under the eyeball where there was a defect in the floor of the orbit and the coronoid process was sutured with chromic catgut to the mesial cut edge of the superior maxilla. This made a firm support for the eyeball to prevent its drooping down (Semken).

A large tongue pedicle flap was cut from the forehead on the right side with the pedicle in front of the ear and low down. This flap was well nourished, containing the temporal artery. The flap was put in place and fitted the defect on the cheek, nose, and upper lip perfectly. It was most carefully sutured with interrupted silk sutures, being particular to make an exact suture line along the nose with no possible inversion of skin edges.

The defect on the forehead was covered with a Thiersch skin graft taken from the thigh. A careful dressing was applied. A Levine tube was placed through the nose as soon as the patient was awake in order to give food.

The wound healed by primary union. On the 21st postoperative day the flap was divided along the posterior line of the original skin incision allowing the pedicle to be unfolded and replaced and realined with the tissues on the forehead after the Thiersch graft on the forehead had been sufficiently excised. This replacement of the flap brought the temporal hair margin into normal position. Primary union occurred and the patient was discharged from the hospital one week later.

The pathological report showed basal cell and squamous cell epithelioma, actively growing. The admixture of squamous cell epithelioma on the basis of an old basal cell epithelioma is seen not so rarely, especially in those lesions which have been irradiated over a prolonged period of time. The accompanying photomicrograph shows the basal cell areas and the prickle cell areas taken from the same lesion (Figs. 4 and 5). The decalcified bone of the outer wall of the antrum showed that the tumor went down to the periosteum but did not actually involve the bone.

It is now 14 months since the operation and there is no evidence of recurrence. There is quite a depression on the cheek which could be overcome by a transplantation of fat under the flap if the patient desired (Figs. 6 and 7). At the present time, however, the patient is satisfied with the condition and is back at work as an executive in a large corporation.

This mutilating operation could have been avoided if the original lesion, while small, had been excised and the wound sutured or a small skin graft temporarily put in place.

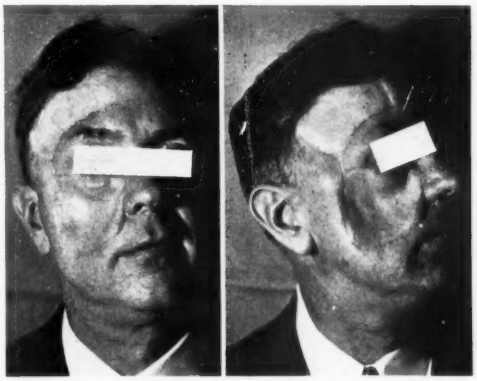

Fig. 6, left. J. C. Anterior view 3 months after operation.
Fig. 7. J. C. Lateral view showing Thiersch graft on forehead and replaced pedicle below.

CASE 2. J. R., aged 45 years. This patient was admitted to the surgical service of Dr. Carl Eggers at the Lenox Hill Hospital. He was a chauffeur and while fooling with some other chauffeurs he had been burned on the right cheek by a lighted cigarette butt 15 years before admission. A bright red spot remained on the cheek and a small opening developed with a slight exudative discharge. He went to a physician who curetted it and it healed. One year later it recurred and was again curetted by a physician. It once more recurred and in 1929 the patient read in a newspaper of curing skin cancers with an escharotic. He sent for the preparation and applied it. How severely this burned him is shown in the accompanying photograph (Fig. 8). He applied it for 7 days. The growth dropped off with the paste, the patient stated, and did not bleed (Fig. 9). The wound slowly healed on the surface but there was still malignancy growing underneath the scar. It broke open again in December, 1934, and at this time the patient was admitted to the Lenox Hill Hospital by Dr. Eggers.

On examination he was found to have an infiltrating lesion on the right cheek adherent to the underlying bone, running up to the nasolabial fold and down onto the lip. The angle of the mouth, as shown on the photograph, was markedly pulled outward and upward and an area of ulceration was present with the bone of the superior maxilla as the base of the ulcer. The gingival fold of mucous membrane was involved and a probe could be inserted from the ulcer into the mouth cavity along the gingival fold (Fig. 10).

Here again an extensive mutilating operation was required to get rid of the entire lesion. Early excision and suture at the time the lesion was first curetted or when it had recurred for the first time and was once more curetted would have cured the lesion and avoided an extensive operation.

Under colonic ether oil anesthesia, on February 14, 1935, the ulcer was cauterized and covered with gauze to prevent implantation. The lesion was widely circumscribed with the cautery knife. The mucous membrane angle of the mouth was saved by making an incision through the lower lip, ¾ inch from the angle of the mouth and then going upward close around the angle of the mouth,

Fig. 8, left. Recurrent epithelioma of cheek following curettement.

Fig. 9. Appearance of cheek following use of escharotic.

completely through the full thickness of the lip and on into the upper lip and up to the ala of the nostril. This permitted the angle of the mouth and upper lip to be reflected mesially. The incision then went around the tumor to the cheek and with a long swing down onto the cheek and through the cheek to meet the incision parallel with the angle of the mouth. The incision was deepened to bony landmarks underneath. A chisel cut was made through the hard palate parallel with the alveolus and then through the alveolus at a safe distance anterior and posterior to the perforation in the gingival sulcus. The entire outer wall of the antrum was removed with the tumor by chisel cuts through the bone. The tumor was lifted out including the mucous membrane on the upper inner side of the cheek. The lip was resutured and the angle of the mouth thereby reconstructed. This left a large defect with an opening into the mouth where the alveolar margin with a small portion of the hard palate and the mucous membrane of the cheek had been removed (Figs. 11, 12, 13).

This defect was closed with a large, long tongue pedicle flap taken from the right forehead with the temporal artery in the pedicle and the base of the pedicle in the temporal region. The entire denuded area on the forehead and the

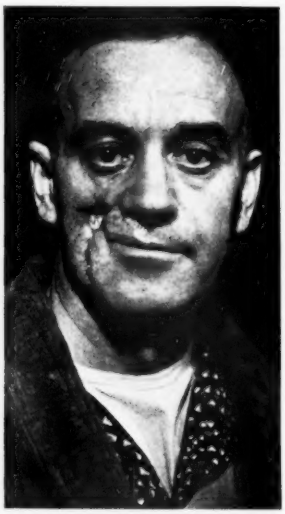

Fig. 10. Epithelioma of cheek adherent to maxilla showing angle of mouth drawn up before operation.

portion of the pedicle of the flap where it jumped across the normal skin of the cheek was covered with a single Thiersch skin graft and a small Thiersch skin graft was sutured on the inner lower one-third of the flap to replace the lost mucous membrane. Then the entire flap was sutured carefully into the defect. All of the Thiersch graft and flap healed by primary union and 10 days after the operation the wound was found to be perfectly dry as shown in the photograph (Fig. 14). Three weeks later the pedicle was divided and the flap sutured into place on the cheek. The Thiersch graft on the inner side of the flap had taken and the upper part of the flap was adherent to the underlying tissues. The Thiersch graft which had healed to the pedicle of the flap was excised and also that portion of the graft on the forehead necessary to permit the remaining pedicle to be

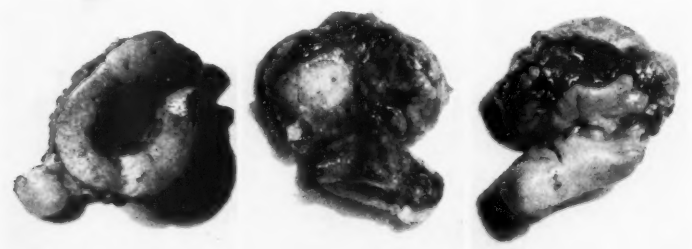

Fig. 11. Fig. 12. Fig. 13.

Fig. 11. Outer surface of tumor showing alveolar margin skin of cheek, and carbonized ulcer.

Fig. 12. Inner surface of tumor with inner wall of antral plate and alveolar process below.

Fig. 13. Perforated gingival sulcus with mucous membrane of cheek above and alveolar process below.

replaced into its former position and sutured. Primary union occurred (Fig. 15). The opening into the antrum where the alveolar margin and small portion of hard palate had been removed slowly contracted and finally closed and a slight revision of the gingival sulcus later was necessary.

It is now 20 months since the operation and there has been no evidence of recurrence.

Pathological examination showed the lesion to be a basal call epithelioma involving the bone and soft parts and also the gingival sulcus and mucous membrane. Here again an extensive mutilating operation could have been avoided if an early simple radical procedure had been employed.

CASE 3. E. B.[1] This patient was treated in March, 1922 by a radiotherapeutist in an upper New York State city for an epithelioma at the ala of the left nostril. Her physician states that it responded very readily but recurred in 1924 and she was then treated with a surface application of radium. This also seemed to be effective but there was a recurrence in 1925 which was again treated with radium. A further recurrence in 1927 was again treated with radium. This time the lesion did not respond readily and two removable platinum emanation seeds of 2.99 millicuries each were inserted into the active margin and left for 10 days. Nearly complete healing resulted from this application but in August, 1928, there again seemed to be activity in the lesion. This was treated with heavy filtered radium in October and also in December. The growth did not respond. A perforation had occurred through the ala into the nares and her physician suggested electrocoagulation and referred her to New York for consultation.

Examination revealed that we were dealing with a lesion at the junction of the left ala of the nose and cheek. It involved the cheek, a part of the upper lip, and had grown into the floor of the nose involving the inferior turbinate body and had transgressed on to the left side of the septum of the nose. The accompanying photograph shows well the outward extension of the lesion but does not show its growth into the nostril itself. The total destruction of a part of the ala was undoubtedly due to the cautery action of the radium but this growth was one of those overlying cartilage and bone which was radioresistant and should have been excised surgically at an earlier time (Fig. 16).

It seemed to us that an operation planned in such a way as to get well beyond the margin of the tumor on all sides as well as in the depth would be the only procedure which would hold out any hope for the patient. Such a procedure would require the removal of the left side of the nose, a portion of the cheek, the upper lip, lower portion of the columella, the floor of the nose with the underlying hard palate, a portion of the septum of the nose and the outer wall of the nose with a portion of the superior maxilla forming the outer wall of the antrum. If this could be done and the incision carried through the soft parts as well as through the bony structures well beyond the margin of the lesion a complete radical removal of the tumor was possible. This large defect would then have to be closed by a reconstruction operation using a pedicle flap from the cheek, swinging this forward to make a new cheek and upper lip and a rhinoplasty would have to be done from the left forehead to make a new side of the nose. The opening from the buccal cavity to the nose and antrum by excision of a "V" from the hard palate could later be closed by a properly fitting denture.

This procedure was discussed with the family and with the patient and consent was given for operation.

On February 9, 1929, now 7½ years ago, this patient was operated upon under colonic ether oil anesthesia in the New York Skin and Cancer Hospital. A temporary ligature was placed around the external carotid artery as practiced and advised by Dr. George H. Semken. This is a most valuable addition to any extensive operation on the face and upper jaw.

[1] Case presented before Surgical Section, New York Academy of Medicine, May 4, 1934.

Fig. 14, left. Pedicle flap healed in place, defect on forehead, and under surface of pedicle closed with Thiersch skin graft are shown in this illustration.

Fig. 15. Flap healed in place, pedicle returned to forehead. Two months after operation.

An incision was then made along the bridge of the nose and on the left side across the lower margin of the nasal bone, on to the cheek, surrounding the ala down to the angle of the mouth and staying well away from the margin of the tumor. The incision was then made from the angle of the mouth along the vermilion border to the midline. A large pedicle flap with the base along the infra-orbital margin was then fashioned with a long sweep back toward the ear and toward the lower margin of the mandible and forward to the angle of the mouth and from there upward to the line of excision. This flap of skin with subcutaneous tissue was dissected upward; it was nourished by branches of the infra-orbital artery. The original incision was deepened to the bony landmarks, the vermilion border and the mucous membrane of the upper lip being saved to a point ¼ inch from the gingival sulcus. The upper lip was then completely divided in the midline and this flap of mucous membrane of upper lip without overlying skin was turned outward thus exposing the alveolus. On the cheek the incision was deepened to the external surface of the superior maxilla, and a chisel cut was made through the outer wall into the antrum and upward toward the nasal bone. The latter was chiseled across, and an opening was made into the nasal cavity along the left side of the septum through the entire thickness of the nose. An incision was made across the columella and through the cartilage of the septum, and the septum was separated from the mucous membrane of the right side of the nose. The septum was then divided backward to a point behind the margin of the tumor. A chisel cut was then made through the alveolus and palatal process just to the right of the midline and backward to a point behind the plane of the tumor. A second chisel cut was made through the lateral alveolus and hard palate backward and inward to meet the previous cut through the palatal process. A cut was then made upward through the vomer, thus permitting the tumor mass with its surrounding structures to be completely removed in one piece (Figs. 17 and 18). It was found that the tumor had not broken through into the antrum and that the excision

Fig. 16, left. Carcinoma at ala of nose involving nose, cheek, floor of nose, septum, and portion of upper lip.

Fig. 17, right above. Specimen showing ala of nose, cheek, upper lip, and columella. Cancer growth into floor of nose also shown.

Fig. 18, right below. Extension of tumor into floor of nose, floor of antrum shown above with palate and vomer below and to the left.

had been safe on all sides including the entire floor of the nose. The bony cuts were gently seared with a cherry red gas cautery to prevent any possible implantation and to prevent absorption by the formation of an eschar. An Einhorn duodenal tube, which we used at that time in place of the now handier Levine tube, was then introduced with the help of an Einhorn duodenal tube introducer and brought out through the right nostril.

The repair of the large resulting defect was brought about by swinging the large cheek flap forward and suturing it into place, thereby reconstructing the upper lip, cheek, and vermilion border. The lateral wall of the nose was reconstructed by means of a pedicle flap which was taken from the left side of the forehead and turned downward. The entire defect on the forehead and inner side of the flap was covered with a Thiersch skin graft. The portion on the rhinoplasty flap was sutured in place with plain catgut. The nose flap, the medial margin to the skin of the nose and the outer margin to the skin of the previously placed cheek flap were then sutured into place. The cavity of the nose was packed with iodoform gauze held in place by mattress sutures through the hard palate. The defect at the posterior portion of the cheek, where the large cheek flap had been swung forward, could be closed completely by undermining the skin edges and suturing. If this suture is not possible a temporary Thiersch graft can be placed in this area.

The patient made an uneventful recovery and was out of bed on the sixth day after operation and all the wounds healed kindly by primary union. On March 9 under local anesthesia the pedicle of the nose flap was divided and implanted into the nose. The Thiersch graft, which had completely taken, was then dissected free from the remaining portion of the pedicle and from a portion of the forehead, in this manner making it possible to reimplant the pedicle into the forehead. Primary union of the wounds occurred (Fig. 19).

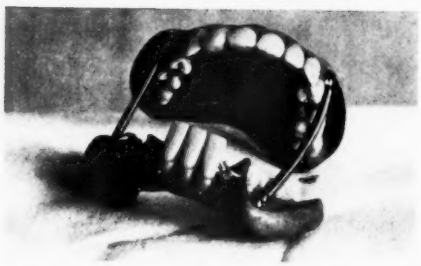

Fig. 19, left above. Patient, 8 weeks after operation showing all wounds healed.

Fig. 20, below. Type of denture used in these cases with spring action holding plate against the defect in the hard palate.

Fig. 21, right above. Patient, 5 years after the operation.

As soon as healing and contraction had taken place we were fortunate in having Dr. Edward Kennedy of New York, one of our excellent dentists, who was at that time connected with the New York Skin and Cancer Hospital, make a denture of upper and lower teeth. The denture was equipped with spring action to keep apart the upper and lower plates. This spring also holds the upper plate against the opening in the upper jaw without suction. When the patient chews or closes the mouth, the plates close against the spring action (Fig. 20).

Pathological examination showed that there was a growth of basal cells arranged in nests at all sides of the ulcer and a pathological diagnosis of recurrence of basal cell epithelioma was made. (Pathological report, No. 11690, February 12, 1929, New York Skin and Cancer Hospital, Dr. Jessup.)

It is now over 7½ years since this operation was performed and there has been and is at present no evidence of the growth (Fig. 21).

CASE 4. T. L., aged 47 years. For the past 8 years this patient had had a pimple on her nose, dating back to 1924. It had always remained the same. Lately, she scratched this pimple and 2 months before admission to the hospital she noticed a lump in the left cheek very close to the nose. The skin in this area became very red. She was admitted to the New York Skin and Cancer Hospital on one of the other surgical services. She was found to be suffering from diabetes and locally presented an oval, raised, fleshy and

projecting lesion, about ½ centimeter in diameter. Above this and extending laterally toward the left cheek was a stony hard mass about 1 centimeter in length. The main portion of the lesion was close to the left nasolabial fold. She was operated upon on March 4, 1932, after the diabetes had been brought under control. An excision was made down to the cartilage and down to the muscles of the face. It was found on examining the specimen in the gross that the excision was close to the margins of the tumor on all sides. Therefore, a further skin excision was made about ¼ inch beyond the previously excised lesion. The wound edges were approximated as far as possible and a small Thiersch graft was put in place.

Pathological examination showed that the tumor was a basal cell epithelioma with invasion of the new-growth up to the border. The patient was observed by this surgical service for a period of time and on January 12, 1933 a recurrence of the tumor was diagnosed. This time the surgical service considered further excision under local anesthesia due to the fact that the lesion was overlying cartilage and a Thiersch graft was to be put in place. However, before this was done the patient was referred to the Radium Department which advised that radium be used, as they believed that the lesion would respond well to radium. This radium was applied on January 17, 1933 and she was observed in follow-up clinic from February until August 1. In October, 1933, a definite recurrence with activity in the growth was observed in the follow-up clinic and the patient was referred to the hospital. This time the patient was admitted on our service. The condition present was practically identical with the previously reported case as can be seen in the accompanying photograph (Fig. 22). Here again the lesion involves the nose, cheek, floor of nose, portion of the columella with the underlying bony structures possibly involved. A cure of this condition could be obtained only by a radical removal of the entire area making the division lines of the skin, cartilage, and bone through areas not involved.

After it was determined that her diabetes was well under control, operation was performed by us on October 18, 1933. The ulcer was coagulated and covered with gauze. A temporary ligature of the external carotid artery was placed. The lesion was excised from the bridge of the nose, onto the cheek to the angle of the mouth, along the vermilion border to the midline, up to the columella, and the mucous membrane of the lip was completely divided in the midline and reflected outward. The mucous membrane was then divided along the gingival sulcus. The incision was deepened down to the bony surface of the maxilla. Chisel cuts were made into the antrum upward to the nasal process of the superior maxilla and across the nasal bone. An incision was made into the nose just to the left of the septum. The septum was divided across above the level of the floor of the nose and backward beyond the margin of the tumor. The mucous membrane on the right side of the nose was separated from the septum. A chisel cut was then made through the alveolus and the hard palate on the right side of the midline backward and somewhat toward the left. Another chisel cut was made on the outer margin of the alveolus through the floor of the antrum, backward and mesially to meet the previous one. A chisel cut was then made upward through the vomer, thereby freeing the entire specimen which could be removed in one mass (Fig. 23). The cheek and upper lip were reconstructed by means of a large pedicle flap from the remainder of the cheek with the pedicle above, swinging this forward and suturing it in place. This reconstructed the cheek and the lip. The side of the nose was reconstructed by a pedicle rhinoplastic flap from the left forehead with a Thiersch graft on the forehead, on the pedicle, and on the inner side of the flap. An Einhorn tube was put in place and the cavity was packed with gauze (Fig. 24).

The patient made an uneventful recovery except for the fact that a small margin of mucous membrane along the vermilion border near the midline sloughed. On November 10, 1933, under local anesthesia the pedicle of the rhinoplastic flap was divided, implanted on the nose, and the remaining portion of the pedicle was replaced on the forehead after excision of a sufficient amount of Thiersch graft from the pedicle and from the forehead (Fig. 25).

Pathological examination revealed that we were dealing with a recurrent basal cell epithelioma, and apparently from sections taken from it, the growth had been excised safely and widely on all sides.

The patient was closely observed in follow-up clinic each month and in the following year it was noticed that as the flaps contracted the nose was drawn over toward the left. On the top of the nose there seemed to be a swelling under the skin which was watched from month to month. There was no ulceration inside of the nose nor of the skin and this swelling remained about stationary. It was observed in April, 1934, and notation of it was made each month following but no increase in size could be noted. It was thought that it was due to the traction of the nose over toward the left and that it probably was the cartilage of the remaining portion of the septum, as this area was distinctly removed from the primary original lesion on the side of the nose. However, the possibility of malignancy was considered, and also the possibility of a chondroma of the cartilages of the nose and at one time due to some enlargement of the sebaceous material of the skin of the nose to the right side of the rhinoplastic flap, a diagnosis of early rhinophyma was made and superficial x-ray therapy was advised for a short period of time as a trial. Three treatments were given, two in October and one in November, 1934. It apparently seemed to control the superficial skin lesion but the subcutaneous swelling remained and a note was made in follow-up on March 20, 1935 that it was suspicious of a possible malignancy (Fig. 26). On June 19, 1935 in follow-up clinic, it was decided that there was activity on the bridge of the nose at the junction of the flap with the skin. It was impossible to determine from clinical examination after consultation with various surgical departments as to whether this lesion was benign or malignant but as there was definite evidence of activity operation was advised.

Therefore, on July 1, 1935, again under colonic anesthesia, this area was completely excised. The top of the nose, the right side of the nose, the entire septum and the cartilages of the nose and a portion of the previous rhinoplasty flap from the left side were removed. The excised tissue was sent for frozen section and a diagnosis was made of recurrent basal cell epithelioma and tumor close to the line of excision. Therefore, immediately a further portion of the septum was removed and skin was taken through the complete thickness of the nose all the way around the margin. Frozen section of this tissue showed it to be safe on all sides except toward the right where it was close to the excision and therefore more of the nose on the right side, almost down to the nasolabial fold, was removed. A small narrow margin of the nares on the right side that had been saved was then sutured, reconstructing the opening of the nostril. A rhinoplasty, this time from the right side of the forehead, was shaped with the pedicle including the right angular artery. This was the first occasion that we had had to do a bilateral rhinoplasty from the forehead and we were interested to find that it was technically feasible to cut across the previously raised pedicle of the rhinoplastic flap from the left side. This large flap was turned down and a Thiersch graft was placed

Fig. 22.

Fig. 23.

Fig. 24. Fig. 25.

Fig. 26.

Fig. 27. Fig. 28.

Fig. 22. Ulcerated perforation at nasolabial fold with infiltration into cheek and upper lip.

Fig. 23. Outer surface of specimen showing skin of nose, cheek, and upper lip. Inner surface of specimen showing extension of tumor into nose involving floor of nose, septum, and inferior turbinate area.

Fig. 24. Cheek flap swung forward and rhinoplasty flap from left forehead in place.

Fig. 25. Pedicle of rhinoplasty flap divided and implanted. Pedicle returned to forehead.

Fig. 26. Appearance several months later. Note swelling on bridge of nose exact pathology of which was not definitely understood at this time.

Fig. 27. Patient, following complete removal of right half and bridge of nose with exception of margin of ala. This defect was closed by rhinoplasty from right forehead. Note Thiersch graft on other side of forehead and scar of pedicles in middle of forehead crossing one another.

Fig. 28. Profile view following double rhinoplasty.

on the forehead, on the pedicle, and on the inner side of the flap as had previously been done in the first operation from the left forehead. The flap healed kindly in place and the pedicle was later divided, this time to be sure of proper nourishment, leaving it in place for 6 weeks instead of 3. The flap was implanted on the nose and the pedicle returned to the forehead (Fig. 27).

Pathological report showed that what we had been observing for a period of months on the bridge of the nose the pathological nature of which we did not know was a typical recurrent basal cell epithelioma. On December 16, 1935, the rhinoplastic flap was revised, excess tissue was excised, and a smooth junction was obtained. It is now 3 years since the first radical operation and 14 months

since the second operation, and there has been no evidence of recurrence at present. The cosmetic result is satisfactory and, with a denture similar to the one used in the previous case, the patient is comfortable and able to go about her work (Fig. 28).

Here again we have a case in which two mutilating operations were required with extensive plastic reconstruction operations in order to overcome a recurrent lesion which probably could have been avoided if in the first operation the lesion, definitely overlying cartilage, had been completely removed with the underlying cartilage rather than an attempt made to save the cartilage.

CONCLUSIONS

These cases of recurrent basal cell epitheliomas of the nose and cheek are reported for the following reasons:

1. It seems best to advise that radical and thorough excision of the basal cell epitheliomas overlying cartilage and bone be done as the best method of treatment and that the underlying cartilage and possibly bone should be removed with the lesion.

2. The primary early lesion may be treated by radium or x-ray if they are used by experts and the dosage so given that the lesion is completely destroyed without damaging the underlying cartilage. If, however, recurrence occurs even though x-ray and radium were used by experts the case should be immediately turned over to surgery as the lesion is probably radioresistant and further radium or x-ray will be of no avail.

3. Surgical excision in recurrent cases must be planned so as completely to surround the lesion on all sides as well as in the depth irrespective of the cartilage or bone that has to be removed.

4. "Temporary ligation" of the external carotid artery by angulation will save a great deal of blood loss during the excision of the lesion and will preserve the full blood supply for healing following reconstruction plastic closure.

5. Gwathmey's colonic ether oil anesthesia makes these lengthy procedures possible and seems to be the ideal anesthesia for these types of cases.

6. The Einhorn duodenal tube introduced into the stomach with an Einhorn introducer at the time of operation, or the introduction of the Levine tube immediately following the operation when the patient can swallow, makes it possible to start fluids and nourishment immediately following operation and will keep the operative field dry.

7. Immediate closure of a large defect after the malignant lesion has been thoroughly removed seems preferable to leaving the wound wide open for observation for months in order to look for recurrence. This seems logical from the economic, psychological, and clinically practical point of view.

Of these 4 cases of extensive recurrent epithelioma of the nose or cheek, one case has remained well 7½ years since operation, a second case 3 years since operation, a third case 19 months, and a fourth case 14 months.

SIGNIFICANCE OF THE "FOLDED FUNDUS" GALL BLADDER

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SINCE the introduction of gall-bladder visualization, the shape and size of the gall bladder have been studied and deductions have been made as to their clinical significance. The importance of the roentgenologist recognizing anomalous shapes of the gall bladder is obvious. The surgeon too must recognize variations in shape of the normal gall bladder so as not to attribute to infection, adhesions, or disease of adjacent organs apparent deformities that may be noted. Recently Gross reviewed anomalies of the gall bladder to emphasize the importance of their recognition by x-ray study or at operation. It is the purpose of this presentation to call attention to the most common anomaly of the gall bladder: the "folded fundus" (Fig. 1). Bartel (3) in 1916 recognized this type of gall bladder, described it, and suggested the name *Phrygische Mutz*.[1]

GROSS ANATOMY

Examination of gall bladders with folded fundi shows considerable variation in shape of the body, neck, and cystic duct. Two varieties are noted. In the first a complete bend is externally visible. In the second only a constriction or indentation is noted. In an excellent review of the subject and from a study of his own material, Boyden suggested the following terms which appear to be descriptive and adequate: (1) serosal type of folded fundus (Fig. 1, a); (2) retroserosal (concealed) type of folded fundus (Fig. 1, b).

In the serosal type, the peritoneum follows the bend in the fundus and is reflected upon itself as the fundus rests on the body of the gall bladder. There are flimsy attachments (fetal ligaments) which on mild traction yield readily along a line of cleavage. This separation permits straightening of the gall bladder with obliteration of the fold. In the retroserosal type—the surface of the gall bladder at the fundus appears to be constricted. However, removal of the serosal layer reveals a folded fundus. Exposure of the interior of the gall bladder permits demonstration of the mucosal fold projecting into the lumen of the bladder (Fig. 4, b). When traction is made on the fundus after the serosa has been separated, the fold disappears and no mucosal partition is present in the interior of the gall bladder. There is present, however, a constriction at the site of the fold. From these findings it may be inferred that the folded fundus is present, because there is insufficient space in the liver bed for its full length. The fold occurs for accommodation of the gall bladder in the fixed and limited gall-bladder bed of the liver. Its relation to the embryology of the gall bladder has been demonstrated.

EMBRYOLOGY

Boyden reconstructed graphically the gall bladder in a 15 millimeter embryo at a stage when it consists of a solid epithelial tube lying in the mesenchyma of the gall-bladder fossa (Fig. 3, e) and made the following observations. Three normal anteroposterior bends were noted in this bed of the gall bladder. One, at the summit of the cystic duct; a second, near the site of the neck of the gall bladder; a third, at the junction between the body and the fundus. The third fold is usually absent in the adult but when present is believed to play a deciding rôle in the formation of the Phrygian cap. Two factors seem to be involved. First, there must be a natural variation whereby certain embryos have a longer gall-bladder fossa than others, thereby permitting full development of the third bend; and second that the corresponding bend in the epithelial anlage of the gall bladder may be accentuated or preserved by a constriction resulting from the method of establishing the lumen (Fig. 3, a, c, d). In the first instance, if the gall bladder should grow faster than its fossa, the fundus would be pushed against the end of the fossa and folded up. In the second instance, should a constriction develop at the bend, through delayed vacuolization, the hour-glass

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These observations were made on material made available to me through the courtesy of Dr. R. Jaffé of the Department of Pathology, Cook County Hospital, Chicago.

[1]Phrygian cap. Phrygia—the name of a large district in Asia Minor in ancient times—derived from a people whom the Greeks called "Freemen" (1500 B.C.). A native Goddess was Cybele who was pictured in artwork with a peculiar headgear since called the Phrygian cap. Such a cap when placed upon the heads of Greek and Roman slaves became a token of their freedom. Louis XVI was compelled to wear it in 1792 in order to show his agreement with the desires of the people. In the same year it was made the mark of a patriot. It is also seen on the head of the Goddess of Liberty, on some coins of the U. S. and has been adopted by some foreign countries being inscribed on their coat of arms.—From the *Encyclopedias Americana* and *Britannica*.

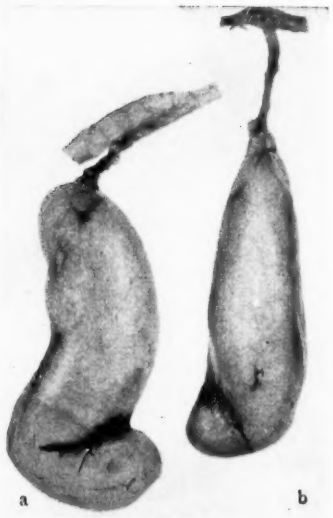

Fig. 1. a, Serosal type of folded fundus. b, Retroserosal type of folded fundus.

type of folded fundus might be duplicated. Such anomalies must be attributed primarily to a peculiar modelling of the embryonic fossa of the gall bladder. There are other factors which determine the type of folded fundus and the position it assumes with relation to the liver bed.

INCIDENCE

The frequency of this anomaly varies with the series reported. In a preliminary report concerning 80 autopsy specimens of gall bladders, Boyden noted 3 in 32 newborns and 3 in 48 adults—an incidence of 7.5 per cent. In a series of 165 cholecystograms each representing a different individual, a folded fundus was noted in 6 cases. In the same series, folds between the body and infundibulum were noted in 24 cases. Thus 18 per cent exhibited kinking, 3.6 per cent showed the folded fundus.

Nuboer found 3 cases in 75 autopsies, an incidence of 4 per cent. Bartel collected 43 specimens at autopsy from individuals ranging in age from 1½ to 78 years. There were 27 females and 16 males in this group. He stated that they were found infrequently.

In our study of 212 specimens, the folded fundus was found in 10 instances, an incidence of 4.7 per cent. However, 8 of the 10 were noted in a consecutive series of 48 autopsy specimens of normal

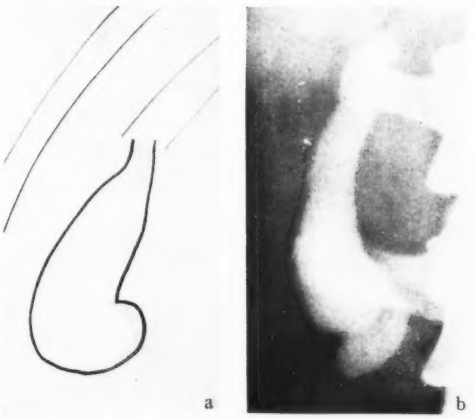

Fig. 2. a, Outline of cholecystogram, Levine's case. b, Folded fundus, Boyden's case.

gall bladders.[1] Numerous isolated cases have been reported and illustrated usually in journals specializing in roentgenology. It is possible that the pathologist sees this anomaly often. In some instances the fold may be attributed to disease and go unrecognized as a congenital anomaly. It may be desirable for the pathologist to record the presence of this common anomaly so that in the future data may be obtained as to its relation to disease of the gall bladder.

NOMENCLATURE

Bartel (3) in 1916 described three anomalous gall bladders observed at autopsy. In each case the fundus of the gall bladder was bent down upon the body of the gall bladder in such a way as to suggest a "Phrygian cap."

Barsony (1) in 1927 described the x-ray appearance as a diverticulum of the fundus (*Spitzendivertikel*). At operation only a shallow indentation was found (apparently retroserosal type). He then called this a false diverticulum (*Pseudodivertikel*).

Levine in 1928 noted a peculiar conformation of the gall bladder in a cholecystogram which corresponded to the description of the Phrygian cap by Bartel. This was the first x-ray diagnosis of this anomaly (Fig. 2, a).

Bronner in 1928 demonstrated mucosal folds in the fundus corresponding to the outline in a

[1] In the course of a study of the physiology of the cystic duct, anomalies of the gall bladder were noted only incidentally. The frequent occurrence of this anomaly in the last 48 specimens is explained by the fact that attention was directed toward examining the contour of the entire gall bladder removed for study. It is possible, therefore, that the incidence is greater than the 4.7 per cent but 16 per cent (8 of 48) does appear to be too high.

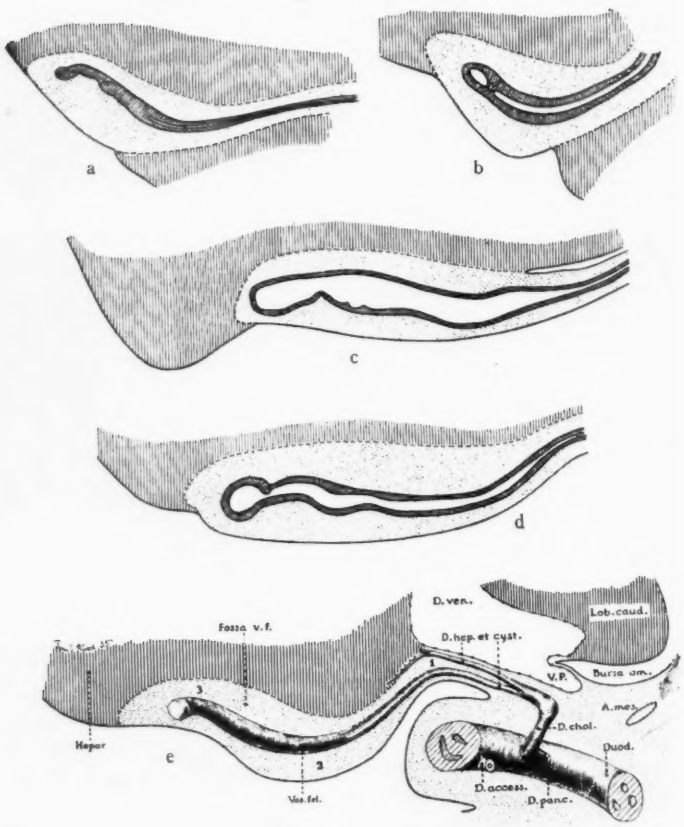

Fig. 3. Graphic reconstructions of the gall bladder and its fossa in 5 human embryos of the Minnesota collection. The first 4 are made from transverse sections and show the gall bladder as it would appear in sagittal section when viewed from the left side. e, is a composite drawing of 26 sagittal sections showing three characteristic bends, *1*, *2*, *3*. a, The lumen is being formed simultaneously at both ends; in the fundus through vacuolization and in the neck by encroachment of the lumen of the cystic duct. Should resolution be delayed, the construction between the two parts might persist even after the lumen is re-established as shown in c and d. b, The embryonic fossa is much shorter than usual, as a result of which the third bend in the gall bladder seems to be absent. (From Boyden, loc. cit.)

cholecystogram. He referred to the anomaly which was noted as congenital kinked fundus (*Kongenitale Fundus knickung*).

Barsony (2) in 1928 following a similar experience referred to it as a folded gall bladder (*Faltengallenblase*).

Camplani noted that the fold in the fundus may be referred to as "cascade" because of its resemblance to a waterfall. The name "clepsydra" has also been applied because of its resemblance to a water clock.

In view of the wide variations (Fig. 1; 4; 5, b) in the degree of folding of the fundus, it appears to me that the term "Phrygian cap" is not an all inclusive term. It is applicable to that group of cases in which extreme folding has occurred. The term "folded fundus" however, covers all cases from the slightest to the most extreme fold.

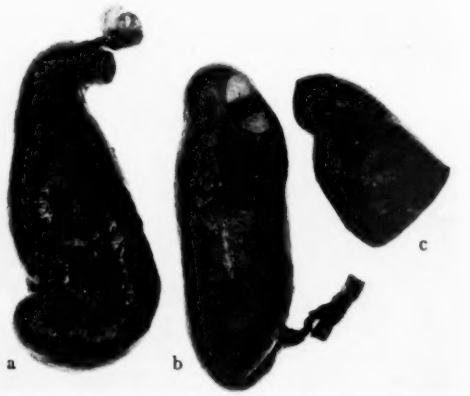

Fig. 4. Examples of folded fundus.

PHYSIOLOGY

Information concerning the functional activities of gall bladders with folded fundi is scant but from the observations on the emptying time of such gall bladders in response to adequate stimulation, the reaction is comparable to that in normal gall bladders without the folded fundus. Boyden was unable to find any evidence of clinical importance in a detailed study of 6 cases of folded fundus culled from a study of 165 cases of normal gall bladders.

A considerable literature has accumulated in which, as a result of cholecystographic examinations, a folded fundus has been demonstrated associated with stones in the gall bladder or with right upper abdominal quadrant pain. As will be pointed out later, this may be merely coincidental.

PATHOLOGICAL IMPLICATIONS

When attention was called to this anomaly by Bartel (3) it was noted that the 3 cases he reported were associated with cholesterol stones. In 1918 the same author (4) reported on 40 additional autopsies in which the same or similar anomalies in the shape of the gall bladder were observed. Three of this later group also had pure cholesterol stones and 1 had a calcium stone. From a study of the clinical histories and pathological observations in these cases, Bartel concluded that such a gall bladder is a sign of constitutional inferiority. It is often associated with lymphatism, status thymicolymphaticus, hernia, genital hypoplasia, and a narrow aorta, and it may be associated with tuberculosis, syphilis, cystic ovaries, and adenomatous goiter. In some

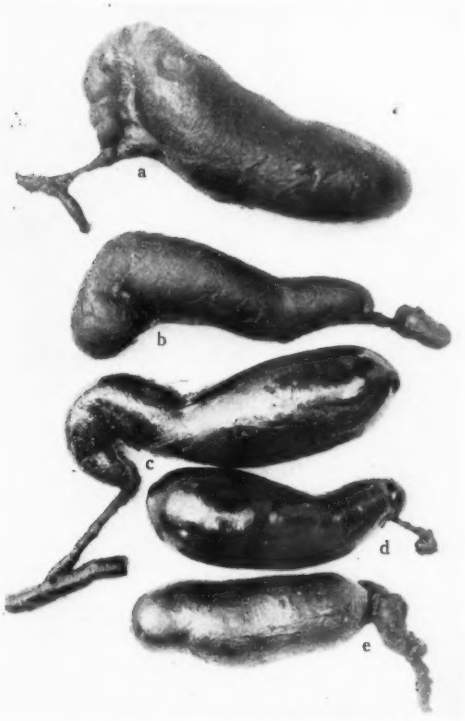

Fig. 5. Variations in shape of gall bladder.

instances the gall bladder was long and narrow suggesting a hypoplastic vesicle.

Bronner in 1928 reported 2 cases of atypical right upper quadrant pain which were relieved by cholecystectomy. Both gall bladders had the mucosal folds revealed in the cholecystograms. He stated that the kinking favored retention of bile in the fundus and interfered with the emptying of the gall bladder.

In 1929 Buedinger described "cholecystitis mechanica" a term to include the cases in which a fold appeared in the fundus of the gall bladder whether it was congenital or as a result of adhesions.

In 1930 Walzel reported observations on anomalies and variations of the gall bladder from a study of cholecystograms, with a view of judging their clinical significance.

In 1932, Camplani illustrated a cholecystogram and also the specimen of a gall bladder with the folded fundus. A study of the mucosal fold at the site of the pouch-like fundus showed slight evi-

dence of inflammation. The mucosa covered a fold of adult fibrous tissue. No stones were present. Clinically the patient complained of pain in the right upper quadrant of the abdomen.

In 1933 Nagel described 2 cases illustrating a fold in what appeared to be a normal functioning gall bladder. The patient had a digestive disturbance associated with right upper quadrant pain. In a second case with a similarly appearing cholecystogram, Nagel was able to show that the fundus of the gall bladder was attached to the duodenum, by adhesions. He thus brought out the importance of differentiating between congenital anomalies and anomalous shapes due to disease.

In 1934 Sigmund also reported a case of right upper abdominal quadrant pain which at operation was associated with a gall bladder with folded fundus. In this report numerous cholecystograms are reproduced showing various shapes in the outline of the gall bladder. Both congenital and acquired variations are shown.

In 1936 Gross reviewed the more recent literature on anomalies of the gall bladder. While the instances of Phrygian cap are not enumerated, he stated that they have been frequently described as a congenital malformation. He continues: "This puckering over of the tip of the gall bladder is usually, if not always, an acquired characteristic."

SUMMARY OF STUDY

It appears to me that in view of the marked variations in the shape and size of the normal gall bladder the folded fundus is of no more clinical significance than the peculiarities in the shape of the neck of the gall bladder (Fig. 5). The most reasonable explanation is the one suggested by Boyden on the basis of his studies of gall-bladder embryology. Whether the fold appears in the fundus, body, or neck, the origin may be identical.

In the specimens that have been examined by the author only one was obtained from a body in which evidence of tuberculous peritonitis was found (Fig. 4, a). This gall bladder was of considerable diameter. This is in contrast to the other specimens which are long and slender in comparison. No stones were found in any of the specimens. In 6 instances where histories were recorded no complaint of abdominal distress was noted. In the remaining 4 death was sudden, and no history was obtainable. However, no abdominal disease was noted at autopsy. While the references cited from recent literature indicate that this anomaly is directly related to disease of the gall bladder and associated with symptoms of upper abdominal pain, the material examined showed no evidence of disease. That these specimens are uniformly free from disease should emphasize the important fact that this anomaly is not of pathological significance.

CONCLUSION

This common congenital anomaly of the gall bladder does not appear to be either the cause or the result of disease.

The anomaly may be associated with coincidental disease of the gall bladder.

It is important that the anomaly be recognized either in the x-ray examination or at operation, since its presence alone does not appear to be an indication of disease.

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PROLAPSE OF THE GASTRIC MUCOSA THROUGH THE PYLORUS

Surgical Treatment

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REPORTS of cases in which the gastric mucosa has prolapsed through the pyloric ring are increasing in number. They are increasing in proportion to the number of patients suffering from gastric complaints who are subjected to roentgenological examination by means of the opaque meal. Lesions of this character may be divided into two groups; those of tumors of the stomach in which a polypoid mass is engaged by peristaltic action and carried through to the duodenum, and those in which the gastric mucosa of the antrum without tumor, is loosened and carried through the pylorus. It is the latter group which is of relatively less frequent occurrence that we wish to discuss.

The roentgenological findings of prolapsing lesions of the gastric mucosa have been well described elsewhere (6, 7). Our interest in the 4 cases reported here centers around the symptomatology; the confirmation of the roentgenological findings at operation in 3 of these cases; the surgical procedures employed in their treatment; and a possible explanation of the etiology of the condition and its correct treatment, as deduced from our observation of these cases.

The actual number of reported cases is not large. During the past 8 years, the roentgenological laboratory which makes these examinations for our group, has made four such diagnoses, two of which were confirmed surgically, among 3000 examinations. During the same period of time the department of roentgenology at the San Diego County General Hospital has had 2 such cases, of which 1 has been confirmed surgically, among 2550 examinations. We have found 9 proved cases of prolapse of the gastric mucosa without tumor formation, reported in the literature. As some of these cases were found in articles not so indexed, there may be others similarly hidden, but we believe the number is still small. The earliest case found was that of von Schmieden in 1911 who stated that no similar case had been described previously; in 1925, Eliason and Wright reported 1 case (3); in 1926, Eliason, Pendergrass and Wright, 2 cases; in 1931, Meyer (K. A.) and Singer, 1 case (4); in 1935, Meyer (W. H.), 1 case (5), and Pendergrass and Andrews, 3 cases (7). Our 3 cases in which operation was performed and the diagnosis thus confirmed, brings the total number of proved cases to 12.

The chief symptom in cases of prolapse of the gastric mucosa through the pylorus is that of periodic distress in the upper abdomen characterized by a sensation of excessive fullness and cramp-like pain in the right upper quadrant after eating; this pain may be severe following the ingestion of rough foods. Vomiting may be a symptom with or without demonstrable obstruction. Other functional gastro-intestinal symptoms which are not related to the condition under consideration may be present. There may be intervals of freedom from symptoms, and temporary improvement may follow the use of a smooth diet. Bleeding has been reported but was not observed in our series. The condition is progressive and symptoms become more pronounced as the mucosa becomes more redundant.

The important finding upon roentgenological examination with the barium meal is that of a negative shadow, containing a central opaque streak, in the duodenum. This opaque line differentiates this condition from that of a prolapsing tumor. The defect may or may not be constant during the progress of the opaque meal. Varying degrees of gastric retention, or none, may be present.

The roentgenological diagnosis of prolapse of the gastric mucosa through the pylorus was made in all 4 of our cases. In the first case, however, a change in diagnosis following later study, to a polyp of the duodenum, led to an incorrect surgical procedure. One case has not been confirmed by operation to date.

The first patient was a spinster, 53 years of age. When she was first seen in September, 1929, she complained of postprandial pain in the upper right quadrant, nervousness, and a tumor of the breast. A carcinoma of the right breast was removed by radical resection about 1 month

From the Rees-Stealy Clinic.
Read before the Pan-Pacific Surgical Association, Honolulu, Hawaii, August 7, 1936.

Fig. 1. Case 1. Prolapse of gastric mucosa through the pylorus with resulting defect in the duodenal bulb. Normal duodenal cap.

Fig. 2. Case 2. Hypertrophy of the rugæ, and defect in the duodenal bulb caused by prolapse of the mucosa through the pylorus.

later. Her gastro-intestinal symptoms, characterized by fullness and severe pain in the right upper quadrant, had started 5 years earlier. She had some distress after each meal but she also had attacks of more severe pain during which she passed considerable mucus in the stools. Two years after its onset, in 1926, an operation which was described as a cholecystectomy, appendectomy, and some procedure for the freeing of a Jackson's membrane, was performed. In 1927, an incisional hernia had been repaired. Her pain and distress after meals had persisted in spite of these surgical procedures.

A roentgenological examination of the gastro-intestinal tract in September, 1929, revealed a normal stomach and duodenum except that one-eighth of the meal remained in the stomach at the end of 6 hours. There was a slight residue following the administration of atropine also. Upon examination, both with and without atropine, 1 year later, in August, 1930, one-fourth of the meal was present at the end of 6 hours. The pyloric portion of the stomach presented a marked prominence of rugæ at both examinations. The filling density of the pyloric portion of the stomach was irregular, but the character of the irregularity did not suggest a malignancy. The roentgenologist felt that the persistent increased 6-hour residue in the stomach could be explained either by an old ulcer defect or by a condition of hypertrophy of the mucosa of the pyloric portion of the stomach. In April, 1931, these findings were still present and in addition the duodenal cap presented a persistent lack of smooth filling of the base. This gave the impression of a pouching of the gastric mucosa through the pyloric canal rather than of an intrinsic defect in the cap. The 6-hour residue, however, was thought to be due to adhesions resulting from the cholecystectomy. Upon exploration of the upper abdomen in May, 1931, very extensive adhesions were found between the anterior abdominal wall and the omentum at the sites of the previous incisions and between the duodenum and the liver. No intragastric or duodenal mass was palpated. It was felt that the pyloric obstruction was caused by these adhesions and no further exploration was done. A posterior gastrojejunostomy was made. A roentgenological examination on July 13, 1931, showed that the meal flowed rapidly through the stoma and did not dilate the distal portion of the stomach. There was no dilatation, constriction or delay in the jejunum and no evidence of irritation at the point of anastomosis. No niche was demonstrable. The antrum and cap were visualized on the screen and no defect in outline was noted. The stomach was empty within 6 hours. For a time the patient's symptoms were relieved. She then began to complain of burning in the epigastric region, and gradually, of pain in the duodenal area with nausea and vomiting. In January, 1933, a roentgenological examination revealed a well functioning gastro-enterostomy. However, the duodenal cap showed a constant circular shadow, measuring approximately 2 centimeters in diameter, within the cap, extending from the base to a point 1 centimeter from the apex; this finding was present also at a second examination following the administration of atropine. At the end of 6 hours there was a small residue in the region of the cap, in the stomach, and in the loop of the gastro-enterostomy. The filling defect in the duodenal cap was considered to be strongly suggestive of a tumor mass within the cap. In March, 1934, the same findings were present and in May the abdomen was opened again. After dissection of extensive adhesions between the under surface of the liver and the stomach to the abdominal wall, an incision 1½ inches long was made in the first part

Fig. 3. Case 3. Hypertrophy of the rugæ, and defect in the duodenal bulb resulting from prolapse of the gastric mucosa through the pylorus.

Fig. 4. Case 3. Slight irregularity of the antrum, normal duodenum, following resection of hypertrophied mucosa; pylorus open.

of the duodenum. Palpation revealed within the duodenum, a soft mass which upon exposure proved to be a redundant ring of gastric mucosa prolapsing through a constricted pyloric muscle. It was evident that our approach was wrong for the proper treatment of the condition. In view of this fact and the pre-existence of a gastro-enterostomy, it was decided to close the pyloric outlet. The entire ring of mucosa was incised to form a cuff and the gastric side closed and inverted with two pursestring sutures of chromic catgut. The incision of the duodenum was then closed. Today the patient still has her original gastro-intestinal complaints. Recent roentgenological examination shows that the closure of the gastric mucosa did not hold entirely, that the pylorus transmits a small amount of barium, and that the gastric mucosa still prolapses into the duodenum.

In this case, prolapse of the mucosa of the antrum of the stomach was observed roentgenologically prior to our first surgical procedure, but its importance was not appreciated. Gastro-enterostomy relieved the gastric retention but did not permanently relieve the symptoms or halt the progress of the prolapse. The increase in the size of the prolapsing mass led to a later mistaken roentgenological diagnosis of duodenal polyp which in turn resulted in an incorrect approach to the true pathological condition and a consequent operative procedure which did not relieve the symptoms or remedy the pathology.

The second patient, a woman 43 years of age, had had two previous operations with deep x-ray therapy, in 1931 and 1933, for malignant disease of the ovaries. Her complaint at this time, June, 1935, was of periodic pain in the upper right quadrant which had been present for several years but of increasing intensity during the preceding 3 months, and associated with attacks of vomiting. The pain was increased by the ingestion of rough foods. A roentgenological study with the barium meal showed that the stomach filled well, and that peristalsis passed through to the pylorus without delay. There was a prolapse of the pylorus into and partly filling the duodenal bulb. The bulb filled well and showed no evidence of ulcer or other pathology. There was no gastric retention at the end of 6 hours. A smooth diet induced temporary relief but the symptoms recurred in 4 weeks' time. Exploration at the time of operation revealed no evidence of the former malignancy of the pelvis. The stomach appeared normal and there was no palpable mass in the region of the antrum or pylorus. The duodenum was normal to palpation. A longitudinal incision was made in the anterior wall of the

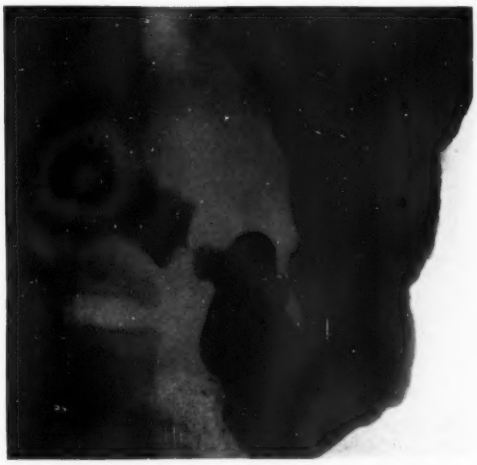

Fig. 5. Same as Figure 4 with pylorus closed.

Fig. 6. Technique of operation: fold of thickened and loosened gastric mucosa as seen through incision in antrum of stomach. Two folds have been resected and the margins sutured.

Fig. 7. Technique of operation: insertion of finger into the pylorus and incision of pyloric muscle.

antrum of the stomach. The gastric mucosa of the antrum was thickened and lay in large oblique folds, the largest about 4 centimeters in length and 3 centimeters in height. These folds could be elevated to form ridges which extended to the pylorus and could be pushed through the pylorus into the duodenum, with ease. The attachment to the muscularis was much looser than is normally the case. Three of the folds of mucosa were elevated separately and excised, care being taken to leave mucous membrane between the lines of excision in order to prevent stricture. The mucosal margins were approximated with running chromic catgut and the muscularis was included in every third suture for fixation. The mucous membrane was then elevated easily, exposing the pyloric muscle which appeared as a white fibrous ring, both smaller and thinner than normal pyloric muscle and with no elasticity. Sectioning of this band was considered, but manual dilatation only was done. The gastric incision was closed in layers and convalescence was uneventful. When last seen this patient was symptom-free on a general diet. Unfortunately, to date, we have not been able to obtain a follow-up roentgenological examination. The pyloric ring should have been sectioned in this case.

The third patient was a man 33 years of age. For 3 months he had had intermittent attacks of nausea and vomiting. The attacks lasted from 12 to 24 hours and during this time any attempt to eat solid food was followed immediately by vomiting. There was no pain with the attacks but nausea persisted for several days afterward. Roentgenological examination of the gastro-intestinal tract showed that the stomach was normal in size, position, and tone, and that peristalsis on both curvatures to the pylorus was present. There were several rounded filling defects in the pyloric antrum, averaging 0.5 to 1 centimeter in diameter which did not interfere with peristalsis. There was no delay in the passage of the barium through the pylorus or duodenum and the duodenal bulb filled normally. At the end of 6 hours the stomach was empty. At operation the pylorus and duodenum were found to be normal to external examination. An incision in the antrum of the stomach similar to that used in the preceding case was made, and the same intragastric findings were observed. The gastric mucosa was thickened and lay in folds that could be pushed through the pyloric ring with ease. The pyloric ring in this case also was constricted and not easily dilatable. Again three large folds of mucosa were excised, and the marginal mucosa was sutured and fixed to the muscularis as in the preceding case. A finger was then forced through the pylorus, and the pyloric ring was sectioned through the peritoneum to, but not through, the mucosa. Again the pyloric sphincter was found to be a thin, white, rigid band. The stomach incision was closed in layers, the mucosal sutures again including the muscularis. The pyloric incision was not closed but covered with a tag of omentum. Convalescence was uneventful and the patient was symptom-free at last report. A postoperative roentgenological examination of the stomach and duodenum showed no areas of diminished density in the pyloric antrum, although there was still some marginal irregularity of the antrum. Duodenal bulb filled normally, and at end of 6 hours stomach was empty.

The fourth patient was a married woman, 45 years of age. Her digestive disturbance, which at first was characterized by dizziness, a great deal of gas and shortness of breath, had started 1 year before she reported to us. One month after its onset she developed pain in the right upper quadrant and constipation. This distress seemed to have no relation to the type of her food. Gas and belching of sour material, which could be relieved by soda or an enema, developed either immediately or from 2 to 3 hours after eating. The pain also awakened the patient at night. A cholecystogram revealed a normally functioning gall bladder. A roentgenological study of the gastro-intestinal tract showed the stomach to be quite normal except for a slight hypertrophy of the rugæ. There was definite and rather marked spasticity of the pylorus at the beginning of the examination but no spasticity or irritability of the duodenal bulb which filled well. There was some lengthening of the pylorus with a protrusion into the base of the duodenal bulb. At the end of 6 hours 2 per cent of the barium still remained in the stomach. Operation has been advised but to date has not been accepted by this patient.

In all 3 cases in which operation was performed there was a definite resistant narrowing of the pylorus and an apparent loss of muscular substance. The body of the muscle was white and definitely thinned which would suggest a fibrous degeneration of the muscular tissue.

ETIOLOGY, HYPERTROPHIC CHANGES, TREATMENT

Eliason and Wright (3) believe that the origin of pedunculated tumors of the pylorus is in a low-grade inflammation of the mucosa which occurs as a "result of chronic irritation (either physical, nutritional, functional, chemical or bacterial) and develops into a local hypertrophy. Once the hypertrophy forms, it is increased mechanically by contractions of the stomach, peristaltic waves, and the pressure of the gastric contents as they are forced by on their way to the pylorus. This results in their being 'pushed along' or lengthened out in the general direction of the pylorus. As the tissue continues to grow it does so at the expense of the stalk or pedicle which is stretched by the engulfing food being forced past and around it. Later when it is sufficiently large and long enough to do so, it is swept or carried into the pylorus by a peristaltic wave and produces the typical 'ball-valve-syndrome' attack of pain."

Our observations have led us to believe that the mechanism is somewhat different. It is our opinion that the narrowing of the pyloric diameter precedes the actual change in the gastric mucosa; that this narrowing of the pylorus is followed by hyperperistalsis on the part of the stomach in its effort to force its contents through the smaller opening; that this action loosens the attachment of the mucous membrane to the muscularis in the constricted area; and that, once the membrane is mobilized, the traction is transmitted by continuity to the antral mucosa which is loosened in turn. When the mucosa is so mobilized that it is caught in the peristaltic wave, it is subjected to the trauma which leads to hypertrophy, prolapse, and later polypoid degeneration (adenoma or papilloma).

The marked hypertrophic changes described as idiopathic benign hypertrophic pyloritis, Billroth hypertrophy (1), etc., were not seen in our cases although the roentgenological findings were suggestive of hypertrophy of the mucosa of the antrum. The roentgenological picture of hypertrophy was produced by an excess of the mucous membrane which had formed in ridges as a result of the stretching of its normal attachment to the muscularis. It is possible that surgical intervention in some of the cases described as idiopathic hypertrophic pyloritis with prolapse into the duodenum would prove the condition to be the same as that described here.

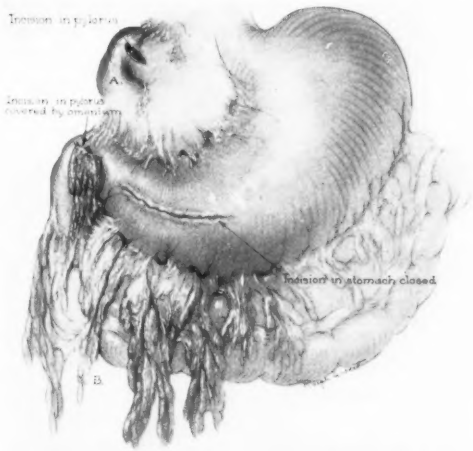

Fig. 8. Technique of operation: operation completed. Incision in stomach closed. Incision in pylorus left open, *A;* covered with omentum, *B*.

We have found no recommendation of any definite method of treatment for prolapse of the gastric mucosa through the pylorus. In the reported cases, most of the procedures described were incidental to the confirmation of the roentgenological diagnosis. They ranged from simple gastrotomy, excision of the folds of the mucosa, pyloroplasty, to gastro-enterostomy. The results varied from good to indifferent.

In planning the surgical approach to these cases, it is necessary to bear in mind that the condition, from its very character, must be progressive, and that if the operation is to benefit the patient it is necessary to treat not only the existing pathology but also the factors that would tend to bring about a recurrence. It must be borne in mind also that the diagnosis is based upon roentgenological findings and that the pathology may not be discovered until after the stomach has been opened; a definite tumor will not be found unless the mucosa has undergone a degenerative change leading to "polyp" formation. Based upon our conception of the cause and mechanism of the type of prolapse of the gastric mucosa which we have encountered, we believe the proper surgical procedure to be:

1. Upper abdominal incision.
2. Exploration.
3. Linear incision in the wall of the antrum of the stomach.

4. Elevation and excision, preferably in an oblique line, of the redundant mucosa, leaving sufficient membrane between the lines of excision to avoid stricture.

5. Closure of the margins of incision with chromic catgut, at least every third suture being anchored deep in the muscularis.

6. Insertion of the finger through the stomach incision into the pylorus and sectioning of the pyloric muscle through the peritoneum to, but not through, the pyloric mucosa.

7. Closure of the gastric incision, again fixing the mucosa to the muscularis.

8. Anchorage of tag of omentum over the pyloric incision.

9. Closure of the abdomen without drainage.

SUMMARY AND CONCLUSIONS

1. Four cases of prolapse of the gastric mucosa through the pylorus are reported. In 3 of these, the diagnosis was confirmed at operation; the fourth has not yet come to operation.

2. In none of the 3 patients operated upon was there any evidence of polypoid degeneration.

3. In all 3 of these cases, the pre-operative roentgenological study showed prolapse of the mucosa through the pylorus. Operation confirmed this diagnosis and revealed in addition a constriction of the pyloric ring.

4. Surgical intervention is the method of treatment in cases in which a roentgenological diagnosis of prolapsing mucosa is made.

5. The surgical technique in these cases includes four important steps: (1) antral gastrotomy; (2) excision of the redundant mucosa; (3) anchorage of the mucosa to the muscularis in the lines of incision; (4) sectioning of the pyloric muscle.

6. It is suggested that the loosening and thickening of the mucous membrane which permits its prolapse through the pylorus, is preceded by pyloric constriction and that this loosening and thickening of the mucous membrane may be the precursors of hypertrophy and tumor formation in this area.

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THE SAFETY FACTOR IN SPINAL ANESTHESIA

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A RECENT publication by Babcock, entitled "Fact and Fancy in Spinal Anesthesia," summarizes well in its title the conception today of this type of anesthesia. The facts about spinal anesthesia have been so beclouded by the publication of fanciful opinions and conclusions based on an insufficient number of experiences that from the literature itself one may draw conclusions ranging from one extreme to the other. In one recent review we are informed that the administration of a spinal anesthetic is unjustified under any circumstances, while another author, after using this agent one hundred times, remarks that it is wholly without danger. Obviously, with such a wide range of opinion, the reader must retire with the observation that it is both safe and unsafe. This opinion, we believe, is the true answer and to make it more specific, we may say that spinal anesthesia is as safe as the administrator.

In the hands of the experienced administrator of spinal anesthesia, this agent will fulfill the requirements of any anesthetic, namely, that it be safe, immediate, efficient, and complete. The small amount of the drug required decreases the toxic action and the parenchymatous damage to the liver, heart, and kidneys. The safety factor requires a wealth of experience and this makes it necessary for the user of spinal anesthesia to be one who administers it regularly. It also requires the operating surgeon to administer the anesthetic and assume full responsibility for its conduction as well as its induction. It is the relegation and division of responsibility which in most instances has resulted so tragically.

At large clinics observation of patients being wheeled into the operating room after the spinal injection has been made outside by an inexperienced resident may lull one's sense of the potential danger. A query as to the reason for the choice of spinal anesthesia in a given instance often brings the response that the subject is unsuited to an inhalation anesthetic because of upper respiratory or other systemic defect. The question as to the drug and dosage frequently requires a hurried consultation with the resident before a response can be made. The beginning of the operation terminates the surgeon's interest in the anesthetic until signs of ineffectiveness appear. The anesthetist sometimes fails to maintain necessary guard over the patient's reactions, the blood pressure, the pulse, or the height of the anesthetic tactile effect. The anesthetist is frequently absented from the patient's head to observe the operation or procure some article. This nonchalant attitude on the part of the surgeon in the use of spinal anesthetic is difficult to understand. The same surgeon will refuse to operate on a patient under general anesthetic without an anesthetist who is thoroughly familiar with every detail of the steps and stages of anesthesia and who possesses a complete knowledge of the drug and all its properties and actions. Under no circumstances would the surgeon permit an untrained interne to administer ethylene. Yet with spinal anesthesia, complete faith is registered in the ability and technique of any interne who is able to locate the spinal canal with a needle.

If a careful survey could be made I believe every "spinal anesthesia death" could be attributed to a personal error in some fundamental point by the administrator or attendant which, by technical experience and a careful study of the physiology and properties of the anesthetic agent, could have been eliminated. The occasional sad experiences of some surgeons have made them reserve spinal anesthesia for use in selected instances only, and this results in its infrequent use, thus increasing the potential danger of the administrator and lessening the limits of safety. It is our contention that such a system is entirely wrong. Spinal anesthesia should be used frequently or not at all. Its occasional use is a needless danger. So we stress a thorough study of the physiology, a careful routine, and a rigid technique.

That such a program, especially stressing the technique, is successful is attested by the fact that in the last 6 years, 4 of which were in association with Dr. W. Wayne Babcock in Philadelphia, over 5,000 spinal anesthetics were administered without a death directly attributable to the anesthetic agent. This group included many patients in a precarious general condition, and the fact that no one was rejected for spinal anesthesia merely because he was a bad risk makes the results more significant. The author believes that anyone who will thoroughly learn and follow with unvarying rigidity the technique of conduction as

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Fig. 1. Position of the patient during the administration of the anesthetic. The patient's back is arched by the attendant who places his arms around the patient's head and by pressing the patient's clasped arms against his abdomen widens the vertebral interspaces. Nervousness or excitement at the time of the introduction of the needle is also controlled by this position. The site of injection is marked with the fingernail and the needle introduced without preliminary local anesthetic. An attendant nurse has hold of the patient's feet ready to elevate them as soon as the needle is withdrawn as a light solution is being used. The tray at left shows the completely equipped emergency intravenous set *ready in the operating room.*

Fig. 1.

well as the induction of the spinal anesthesia, study the drug and its properties, and be prepared to recognize and treat the emergency when it arises, can readily duplicate these figures.

A study of the drug used brings us to a greatly maligned subject. The action of spinal anesthetic is achieved by the bathing of the spinal nerve roots in an anesthetic solution introduced into the free spinal fluid. All of the nerve roots reached by this solution in sufficient strength are temporarily inactivated. Many men, in their anxiety to have their names attached to a procedure, have added various materials to the fundamental drug substance and then attributed the excellent results they accomplished by a carefully followed technique to this added material, whether it be starch, glucose, ephedrine, or bubbles. Fundamentally, there is little change in this action, no matter what substance is added unless the substance varies the specific gravity of the injected anesthetic. From time to time various drugs have been used to cause the anesthetic effect. Cocaine, first introduced in Paris, gave way to stovaine and later to alypin, tropacocaine, and finally to procaine, the drug most often utilized today. In Mexico City cocaine is still a routine procedure and the satisfactory anesthesias attest to the fact that experience and familiarity make for safety no matter what drug is used. Procaine, while not as effective as cocaine and stovaine, is less toxic and because of this property is the drug of choice. Nupercaine, of longer duration, has the disadvantage of prolonging any untoward effects.

Spinal anesthesia may be classed in three categories:

1. *Light solutions* with lower specific gravities than that of spinal fluid are often achieved by the addition of ethyl alcohol (10 per cent). Such a solution rises in the spinal canal and the localization of the anesthetized area is partially controlled by gravity. The position of the patient on the table and the elevation or lowering of the body maintains the anesthesia at the desired level. Babcock's solution and Pitkin's solution are examples of this type.

2. *Heavy solutions.* The specific gravity of the solution is greater than that of the spinal fluid. As a rule operative procedures are carried out, or at least begun, in a modified Fowler position to prevent the anesthesia settling to the upper levels of the canal. Glucose, starch, salt, etc., may all be used to cause this change in the specific gravity. An example of such a spinal method is Barker's method.

3. *Solutions which dissolve* in the spinal fluid without markedly changing the specific gravity depend again on gravity for localization. An example of such a spinal anesthesia is Labat's method. No brief is held for the light or heavy solution. More experience and familiarity with the light solution has made it our choice, particularly as immediate Trendelenburg position is desirable in most operations. The argument which we offer is merely for a thorough knowledge of the drug, technique, action, and possibilities of the solution used.

Fig. 2. The immediate Trendelenburg position is safe when light solutions of a spinal anesthetic are used since they diffuse toward the feet in that position. This position, however, is dangerous when heavy solutions are used since they diffuse toward the head.

Fig. 2.

Dosage. The dosage of the anesthetic varies with the age of the patient, the height of anesthesia needed, the length of anesthesia required, and to some extent the condition of the patient. The size of the dose depends on the size of the spinal canal and not on the size of the patient, and inasmuch as the spinal canal does not grow in proportion to the rest of the body, the amount used for the young is relatively large. Babcock has given one-fourth of an adult dose to a baby 1 day old. A child of 3 years can stand one-third of an adult dose, while at 6 years, one-half of the full amount can be given safely. By the sixteenth year a full dose is well tolerated. The stronger drugs, such as cocaine or butyn, require relatively larger percentages of the adult doses in the young. For example, a child of 1 year can stand one-third the dose of cocaine that his father can take. In general, 12 to 15 centigrams (1½ c.cm. of 8 per cent solution) of procaine is satisfactory for the adult, while 3 centigrams of cocaine is the proportionate amount. The duration of the spinal anesthesia follows roughly the inverse square law.

The action of a given amount of drug depends on certain factors which are: (a) type and strength of the drug; (b) the specific gravity of the solution (light or heavy solutions); (c) the interspace selected for injection; (d) the amount of fluid withdrawn before the injection; (e) barbotage; (f) the force of the injection; (g) the position after the injection.

Each individual factor plays its part and attention to each makes for success and safety.

The danger of incomplete knowledge regarding the properties of the drug used and its action is at once apparent. A few years ago in this city, a well known surgeon had the unforgettable experience of seeing his first, and subsequently his last, spinal patient die on the table while he was scrubbing. The method was adjudged guilty and banished forever from that operating room. Actually, the resident, to whom the responsibility of administering the spinal anesthesia had been injudiciously surrendered, neglected to ascertain

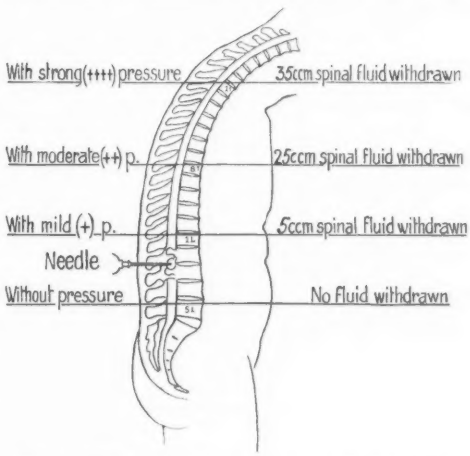

Fig. 3. The effect of the amount of spinal fluid withdrawn and force of injection on the height of anesthesia.

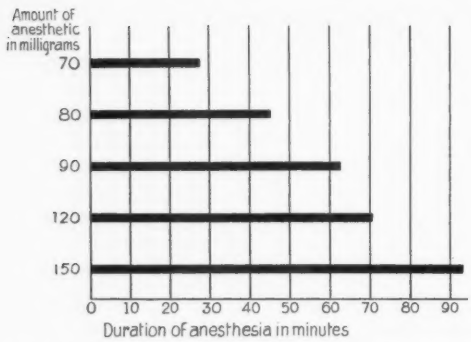

Fig. 4. Average figures based on tactile sensation when a spinal anesthetic with a higher specific gravity than spinal fluid is used.

that the drug was a light solution and therefore would rise in the canal and required immediate Trendelenburg position. Instead, the patient was left in an upright position until in a few minutes the spinal anesthetic solution had reached and paralyzed the vital centers in the medulla. The surgeon could consider no one but himself responsible and this furnishes the example of relegation and division of responsibility which results in sad experiences. Many surgeons do not wish to have any responsibility for the anesthesia, and such an attitude, while possibly judicious, is incompatible with the successful use of spinal anesthesia.

The following standard technique, as used at the Babcock clinic, based on some 25,000 spinal anesthetics, is given, not because some similar technique is not as satisfactory, but because it is desired to impress on the readers that a set form must be followed religiously if one is to be successful in practicing spinal anesthesia.

Technique. The anesthesia is given in the operating room by the operating surgeon after he has finished his preparation for the operation; no one but the surgeon touches the spinal tray—the surgeon filling his own syringe with the anesthetic solution. The patient sits on the side of the operating table with his legs depending. Instead of allowing the patient to sit with his arms on his knees, he is supported by the attendant elevated on a stand, who places his arm around the patient's neck. After arching the sterilized back of the patient the attendant grasps his crossed wrists and presses his hands against the abdomen for counter support (Fig. 1). Using the simple landmarks of the back, the surgeon selects the site of injection; for the usual abdominal operation the first or second lumbar interspace usually suffices. The space is marked with the fingernail and when the spinal solution has been prepared in the syringe the needle is introduced through the skin without preliminary local anesthesia. Experience has shown that a skin wheal is not necessary as the wheal injection causes as much sensation as the spinal needle and the infiltration may cause a loss in the interspace landmarks. The needle is passed until the resistance of the interspinous ligament is met and the stylet removed. The needle is then moved forward until an escape of fluid signalizes the entrance into the dura. To ascertain that the bevel is all in the canal, the needle is rotated. After as much of the spinal fluid as is desired has been allowed to run out, the syringe is attached to the needle and the spinal fluid drawn into the syringe. A lock type of syringe should *not* be used, as the attachment of this type of syringe will often slightly disturb the position of the needle. After the syringe has been filled and diffused, it is injected by barbotage and the needle quickly withdrawn.

Immediately following this needle withdrawal, the trained attendants place the patient in a Trendelenburg position. This is important and unless the attendants are carefully trained there will be a dangerous delay while shoulder supports, etc., are adjusted. The selected assistants, however, make these adjustments after the patient is in the Trendelenburg position, the degree of position depending on the height of anesthesia desired and the dosage (Fig. 2). As soon as the abdominal and other drapes are in place, there will be sufficient anesthesia to start. Should there be delay in anesthesia, the leveling of the table will raise the height of the effect.

Careful blood pressure readings at few minute intervals are important and informative as to the effect of the injection. Pulse and color are also of help as are the patient's reactions. The appearance of nausea and vomiting is usually evidence of the hypotension which always follows spinal anesthesia, and can be partly counteracted by changing the table level as the blood pressure drops. This pressure fall may be from 20 to 80 millimeters of mercury. In the average individual with a pressure of 120 systolic, a fall to 70 or 80 is not dangerous, and is actually the physiological reaction to the vasomotor palsy. The efforts to prevent this fall by injections of ephedrine and other drugs are physiologically unsound, and a perusal of the literature of the past 10 years shows many fatal reactions to the drug (ephedrine) most often so utilized. Should there be an alarming fall in pressure; for instance, to 40 or 50 millimeters of mercury systolic, the introduc-

tion of a saline solution into the veins and the addition of a few minims of ephinephrine hydrochloride will be most efficacious. This solution should be stopped as soon as the drop in pressure is halted, as overstimulation at this stage is also dangerous. The violence of the recovering heart beat after an overstimulation is sufficient at times to make the table tremble, and may be the cause of later cardiac decompensation.

The operating room preparations for the emergency administration of the saline, adrenalin, or glucose solutions are maintained complete and are inspected several times daily. No excuses are accepted for failure in this set-up. The first assistant is responsible for the introduction of the needle into the vein at a given command, and by the time the needle is in the vein the circulating nurse must have the solution in the container, air expelled, and ready to attach. One minute is all that is permitted to elapse before the solution is running into the vein and practice makes this part perfect. If there is difficulty in the introduction of the needle, no time is lost but the vein is exposed by incision. This emergency seldom arises, but when it does life may hinge on the 1 minute lost in attaching a poorly fitted tubing. Again, routine has played a part in the conduction of safe spinal anesthesia. A general anesthesia should never supplement a spinal anesthesia. In this connection an infiltration local anesthesia is invaluable and its assistance in the completion of a difficult operation has not been sufficiently stressed.

There are definite contra-indications to the use of spinal anesthesia just as there are contra-indications to every type of anesthesia. The *hypotension* associated with extreme old age, marked sepsis, shock and hemorrhage, or cardiac degeneration is a contra-indication to all anesthetics, and particularly to spinal anesthetic. A *low pulse pressure* where a high diastolic reading confirms the presence of a poor cardiovascular reserve or *spinal disease*, and especially *neurosyphilis* should indicate the use of some other anesthetic agent. The *absence of trained assistants*, to maintain the necessary watch over the patient and to assist in the resuscitative measures should they be needed, is an adequate reason for employing an inhalation anesthesia. Certain patients who are *hypercritical* and who may later attribute other symptoms to the spinal part of the anesthesia may make the experienced surgeon wary in his choice of spinal anesthesia for such patients. *Nervousness*, *psychoses*, and neurosis on occasions may be contra-indications.

The various tricks, such as the injection of air to restrict the anesthetic to certain levels in the canal, the addition of acacia, ephedrine, glucose and other stimulants to the spinal anesthetic, the turning of the patient to allow the anesthesia to bathe the posterior roots only, to our mind are merely fads. The routine addition of stimulants is contra-indicated as by preventing or reducing the physiological drop in blood pressure, they may throw the regulation apparatus entirely out of control. Various types of special needles are likewise only confusing name plates for their introducers, cluttering up an already obscured technique. Again, as in so many surgical procedures, common sense plays its part. Faddists are always with us, and the attempt to follow their pathway may lead one into dangerous ground.

The high anesthesias for operations around the head have proved successful in certain hands, but personally we neither advocate nor use such types of anesthesia.

CONCLUSION

1. Safety in spinal anesthesia requires the assumption of responsibility by the surgeon for the induction and conduction of the anesthesia.
2. A study of the drug, its properties, and physiological action is a fundamental requirement.
3. A careful routine and a rigid technique must be established.
4. There must be a thorough understanding of an emergency situation and its treatment.
5. The occasional use of spinal anesthesia is dangerous.
6. Spinal anesthesia is as safe as the user.

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PELVIC VARIATIONS IN 300 PRIMIPAROUS WHITE WOMEN

A Clinical Study and a Proposed Classification

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WITHIN the past few years there has been a definite revival of interest in the architecture of the female pelvis and its relation to labor. This has been brought about chiefly through the development of roentgenological methods for studying the pelvis in the living subject and by correlating such observations with the process of labor. Recent studies by competent observers have emphasized the existence of variations in the pelvic architecture of a large part of our female population. Some of these variations may have a distinct influence upon the course of labor and the importance of investigations of this character is manifest.

The knowledge of the occurrence of variations in the pelvis is not new. A half century ago William Turner wrote, "The inlet to the true pelvis presents variations in outline, and in the relative proportions of its conjugate and transverse diameters, has been recognized by anatomists since the form of the pelvis in the different races of men began to be studied." Other observers before and since that time pointed out that "male" characteristics could occur in female pelves. Apparently however none of these older writers suspected that the incidence of such variations was relatively great.

My own interest in this subject began 16 years ago in developing roentgenological methods of pelvic mensuration. During the course of my experience I was impressed particularly by the frequency of the occurrence of pelves in which there existed a relative shortening of the transverse diameter of the superior strait associated frequently with a relative lengthening of the anteroposterior diameter (mesatipellic and dolichopellic types). In 1930 I (6) emphasized the fact that in certain pelves information respecting the length of the transverse diameter of the inlet may be of more importance from a clinical point of view than similar information regarding the length of the anteroposterior diameter.

In 1932 (7) and 1933 (8) I emphasized the occurrence of pelves which did not conform to our concept of the normal and pointed out the intimate relationship between the dolichopellic type and the occiput posterior position. In this latter year Caldwell and Moloy (1, 2, 3) reported the first of their clinical studies on anatomical variations and their noteworthy contributions since have done much to perfect our knowledge of pelvic architecture, especially in its relation to the course of labor.

The purpose of the present communication is to emphasize again the advantages of applying this newer knowledge to practical obstetrics and to present a survey of the results in 300 primiparous white women who have been delivered consecutively at full term in the wards of the New Haven Hospital and in whom roentgenometry of the pelvis has formed a part of the prenatal examination.

It is obvious that if we are to make this newer knowledge of pelvic variations clinically practical we must, as far as reasonable, simplify our terminology. In a recent communication (11) I stated that the shape of the superior strait could serve as a basis of classification which was useful for general clinical purposes. There is nothing novel in this idea which is based chiefly on that of Turner who, in 1885 (14) in a paper entitled "The Index of the Pelvic Brim as a Basis of Classification," divided pelves into 3 groups, viz., dolichopellic, mesatipellic, and platypellic types. In the present classification instead of using the pelvic index as a criterion, as did Turner, I have employed the direct relationship of the anteroposterior diameter to the transverse diameter. Further experience has appeared to justify the use of this classification for clinical purposes and I again present it with slight modifications.

From a practical standpoint there are 4 (3 main, 1 subsidiary) variations in the shape of the superior strait, namely: (1) pelves in which the anteroposterior diameter is longer than the transverse; (2) pelves in which the anteroposterior diameter is equal to, or but slightly less than the transverse; (3) pelves in which the anteroposterior diameter is moderately shorter than the transverse; (4) pelves in which the anteroposterior diameter is excessively shorter than the transverse.

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A diagrammatic representation may be studied in Figure 1. To these four types the following Greek derivatives lend themselves admirably and should become familiar: (1) Dolichopellic type or anthropoid pelvis; (2) mesatipellic type or round pelvis; (3) brachypellic type or oval pelvis; (4) platypellic type or flat pelvis.

1. *Dolichopellic* or anthropoid type. The superior strait is elongated anteroposteriorly.

The anteroposterior or "A.P." diameter is longer than the transverse.

Large, average or small varieties dependent upon the length of the anteroposterior diameter.

Anteroposterior diameter 14 centimeters or more—large dolichopellic type.

Anteroposterior diameter 12 centimeters or less —small dolichopellic type.

2. *Mesatipellic* or round type. The superior strait is round in appearance.

The transverse diameter is equal to or only slightly longer (never more than 1 cm.) than the anteroposterior diameter.

Large, average or small pelves dependent upon the length of the anteroposterior diameter.

Anteroposterior diameter 13 centimeters or more—large mesatipellic type.

Anteroposterior diameter 11 centimeters or less —small mesatipellic type.

3. *Brachypellic* or oval type. The superior strait is transversely ovoid in appearance.

The transverse diameter is between 1 and 3 centimeters longer than the anteroposterior diameter.

Large, average or small pelves dependent upon the length of the anteroposterior diameter.

Anteroposterior diameter 12 centimeters or more—large brachypellic type.

Anteroposterior diameter 10 centimeters or less —small brachypellic type.

4. *Platypellic* or flat type. A small number of pelves in which the superior strait is a transversely elongated ovoid in appearance. This pelvis is probably the result of rachitic influence (*vide infra*). The transverse diameter is greatly in excess (3 cm. or more) of the anteroposterior diameter.

NOTE.—The majority of pelves will fall into the first 3 groups of the above classification. The classification into large, average, and small pelves will be readily comprehended if we remember for large pelves the figures 14, 13, and 12 centimeters or more, for groups 1, 2, and 3, respectively, and for small pelves the figures 12, 11, and 10 centimeters or less for groups 1, 2, and 3, respectively.

It may be pertinent to discuss some features of this classification. I have introduced the term brachypellic, which Turner did not employ, in order to reserve the term platypellic for those pelves which show marked anteroposterior flattening, i.e., a transverse diameter greatly in excess of the anteroposterior diameter. With regard to the use of these Greek derivatives I am more and more in favor of employing them instead of such terms as female type, oval, anthropoid, and such.

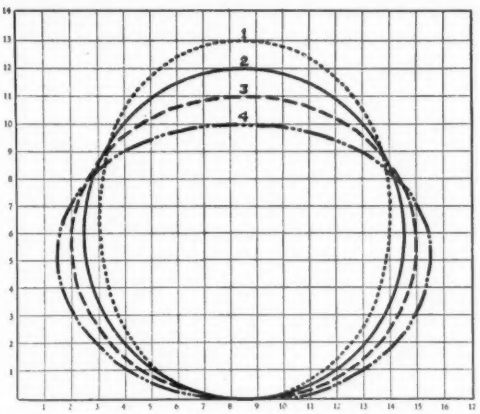

Fig. 1. Diagram showing usual pelvic variations in 4 groups (see text).

The prefixes dolicho, mesati, brachy, and platy are not innovations in modern medical nomenclature and their significance can be readily understood when applied to the superior strait of the pelvis. I am well aware that the value of these terms is chiefly useful in depicting the shape of the superior strait and that in certain instances other terms will be essential to use in qualifying a given pelvis. For example, such terms may be employed as, mesatipellic type with narrow forepart, dolichopellic type with narrow or funnel outlet, etc.

I am much impressed with the usefulness of having exact limits to designate large, average, and small pelves in the different groups. It must be obvious that the criteria for each group cannot be the same; therefore I would stress the usefulness of employing one diameter (anteroposterior) as the measuring rod for this purpose. I am, of course, in full accord with Caldwell and his associates with regard to the obstetric importance of other portions of the pelvis. I do feel, however, that as a basis for classification we should use the conformation of the superior strait and furthermore that from an etymological standpoint there can be no quarrel with these excellent and descriptive terms.

TABLE I.—INCIDENCE OF PELVIC TYPES

Dolichopellic or anthropoid type	Cases	Per cent	Mesatipellic or round type	Cases	Per cent
No. of pelves	49	16.3	No. of pelves	132	44
Large pelves	5		Large pelves	13	
Average pelves	38		Average pelves	95	
Small pelves	6		Small pelves	24	
Narrow or funnel outlet pelves	13	26.5	Narrow or funnel outlet pelves	25	18.9

Brachypelllic or oval type	Cases	Per cent	Platypellic or flat type	Cases	Per cent
No. of pelves	109	36.3	No. of pelves	10	3.3
Large pelves	19				
Average pelves	77				
Small pelves	13				
Narrow or funnel outlet pelves	23	21.1	Narrow or funnel outlet pelves	0	

With regard to pelvimetric procedures in general I would state that in order properly to survey a given pelvis, one should obtain not only a roentgenogram of the superior strait in its anteroposterior aspect but a lateral view of the pelvis as well. With our system of pelvimetry we are able to reproduce in true proportions the essentials of both of these aspects and chart them on centimeter square paper so that they may be incorporated with the prenatal history.

The importance of the lateral pelvic roentgenogram was emphasized in 1929 (5) and in the present series although it has not been employed routinely, we have used the technique freely in those cases where disproportion or other abnormality was suspected. In addition to these two roentgen procedures we employ the usual outlet pelvimetry maneuvers described by Williams and others. With respect to the grid method which we employ and which has been described elsewhere (9, 12), I may say that we find that it is simple, rapid and accurate and has a further advantage in that it is inexpensive. Our present actual cost per film represents an expenditure of one dollar and seventy cents which should make the procedure available for routine ward use.

The present series of 300 cases presents interest from several points of view. The women were all primiparæ, of the white race, and were delivered at full term (i.e., infants weighing 2500 grams or over at birth). The series is consecutive, and all patients were delivered in the hospital and received prenatal care in our clinic. In this series, therefore, such influences as multiparity and premature birth are eliminated, while the influence of race is somewhat minimized by the fact that all patients were white and practically all were American born.

It is significant that brachypellic or oval pelvis was found in only 36 per cent of the series (Table I); this fact will be commented upon later. The incidence of narrow outlet (bituberal distance 8 cm. or less) in 26.5 per cent of the dolichopellic pelves shows the influence of narrowing of the pelvic side walls both in the upper and lower pelvis which is characteristic of this type.

The incidence of operative interference in the series is shown in Table II.

TABLE II.—INCIDENCE OF OPERATIVE INTERFERENCE

	Times
Operative interference resorted to	60
Divided in the following procedures:—	
Cesarean section	6
Version and extraction	6
Forceps operation	48
With outlet or low forceps	31

The incidence of interference according to pelvic type is shown in Table III.

TABLE III.—OPERATIVE INTERFERENCE ACCORDING TO TYPE OF PELVIS

	Forceps operations	Cesarean section	Version and extraction
Dolichopellic type	7	0	0
Mesatipellic type	25	1	1
Brachypellic type	16	2	5
Platypellic type	0	3	0

The incidence of the low forceps operation (31 times as shown in Table II) deserves attention in so much as it is probable that many of these patients might have delivered spontaneously if spontaneous birth were an object in itself. It is our opinion, however, that many primiparous patients may be delivered with less trauma and more satisfactorily by timely episiotomy and low forceps than if let alone. The term "forceps control" or "prophylactic forceps" should perhaps be used for these cases. The incidence of 30 per cent operative interference in the platypellic group is significant (Table III)—in the 3 patients delivered by section the anteroposterior diameters of the inlet were 9.0, 9.0, 8.0 centimeters, respectively.

Breech presentation occurred in the series as shown in Table IV.

The increased incidence of breech presentation in the dolichopellic type is an interesting finding (Table IV). The significance is not clear and

TABLE IV.—BREECH PRESENTATION

	Times	Per cent
Dolichopellic type	6	11.7
Mesatipellic type	3	2.2
Brachypellic type	6	5.5
Platypellic type	0	0.0

further study is necessary before proper evaluation can be made.

Complications of pregnancy occurred in several cases as shown in Table V.

TABLE V.—COMPLICATIONS OF PREGNANCY

	Cases
Heart disease complicating pregnancy	1
Toxemia	6
Advanced tuberculosis	1
Premature separation of placenta	1

It is probable that the group of primiparous white patients, Table V, represents women in the prime of their reproductive life and that pregnancy complications due to disease and to other factors may be expected to be less than in any other group of obstetrical patients.

Mortality and morbidity. In this series there were no maternal deaths and 3 fetal deaths. One fetal death occurred in a patient in whom the membranes had been ruptured for some time previous to her entrance to the hospital and in whom the fetal heart during labor was never heard. The stillborn infant showed evidence of having been dead some hours previous to birth.

The second fetal death occurred following a version and extraction of a moderately large infant (4059 grams) in a patient with a small brachypellic type pelvis (anteroposterior diameter 10.0 centimeters; transverse, 12.0 centimeters). Although the operation, which was done for high arrest after 22 hours of labor, did not present unusual difficulties and autopsy revealed no cause of death, nevertheless the operative procedure was probably the responsible agent.

The third fetal death occurred 2 hours after delivery by midforceps of a very obese patient following a 24 hour labor complicated by uterine inertia. The child weighed 3145 grams and birth injury may have been responsible.

A corrected fetal mortality should exclude the first case and is therefore 0.66 per cent.

TABLE VI.—INCIDENCE OF POSTERIOR OCCIPITAL VARIETY

Type	Primary posterior variety	Persistent	Total per cent
Dolichopellic	12 times	3 times	15 or 29.4
Mesatipellic	12 times	4 times	16 or 12.5
Brachypellic	8 times	2 times	10 or 9.6
Platypellic	1 time	0 time	11 or 10.0

The incidence of posterior variety as noted in Table VI requires some explanation. Undoubtedly where pelvic examinations during labor are largely limited to rectal touch, many primary or early posterior positions of the occiput are not discovered. Nevertheless the incidence as shown in this table represents instances in which there was no doubt in the examiner's mind as to the variety. The comparatively high incidence of posterior variety in the dolichopellic type was pointed out in 1933 in a paper entitled "A Type of Pelvis Intimately Associated with Occipitoposterior Position" (8).

GENERAL CONCLUSIONS

When we consider that even at the present time most of our standard textbooks refer to the "normal female pelvis" as one in which the superior strait is essentially oval with the transverse diameter averaging 2 centimeters longer than the anteroposterior and when we further consider that this same type of pelvis occurs in less than half of our female white adult population (36 per cent of the present series) we surely gain some idea as to the necessity of reconstructing our views with regard to the architecture of the female pelvis.

In a previous communication entitled "What Is a Normal Pelvis?" (10) I pointed out that recent studies suggested that the normal pelvis of the adult white woman was frequently round rather than oval and that from a pragmatic point of view nature probably had reason for this. In the present series the greater percentage of dolichopellic and mesatipellic types must be of significance. I have also previously suggested (13) that the influence of childhood rickets may play no small part in the etiology of many brachypellic or oval pelves. Furthermore, I am convinced that in the platypellic group this disease plays a major rôle.

We have been using roentgenometric methods practically routinely on our wards for nearly 4 years, and we are convinced that by its use many obstetric problems have been simplified. For example the term "test of labor" has practically disappeared from our nomenclature. In none of the cases presented was this measure used and, from the fact that cesarean section was performed only 6 times in 300 consecutive primiparous women, it appears that we have not substituted radical for more conservative procedures. It seems unnecessary to point out that exact dimensions of the pelvis as revealed by roentgenometry are not a substitute for careful obstetrical judgment as developed by clinical experience. The information thus obtained like paint on an artist's easel must be "mixed with brains."

In conclusion I would like to emphasize once more the usefulness of the classification which I have proposed. The employment of the contour of the superior strait as a basis for classification will allow all but the most abnormal pelves to be readily grouped. If other features of obstetrical importance present themselves, such as male type of sacrosciatic notch, narrow forepart, narrow subpubic angle, forward displacement of lower sacrum, these features may be noted. The house staff of our hospital who have delivered practically all of this series have become readily acquainted with this classification and we use it constantly. Our students also easily familiarize themselves with this grouping and I feel that it is therefore readily teachable.

Because of a purposeful limitation of space I have not stressed the work of other observers but the work of Caldwell and his associates, and of Pettit and his group are important landmarks in this newer study of pelvic architecture. Finally, I would state that I am more than ever of the opinion that every woman who is expecting her first baby deserves the advantages offered by roentgenometry of her pelvis.

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HOW SURGERY OF THE COLON AND RECTUM DEVELOPED

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IN THE romance of medicine, the chapters dealing with the development of the operative act as a phase of the healing art are the most fascinating. The evolution of surgical procedures for abdominal pathology, depending necessarily upon the late discovery of asepsis and anesthesia, has come about almost entirely within the last half century. Surgery for external ailments and traumatic lesions encompassed in a large measure the entire scope of the operations of remote antiquity.

Operations on the rectum and colon dating back as they do to the time of Hippocrates, present however a steady, unhurried record of progress. This Father of Medicine, born in 460 B. C., dealt with the treatment of fistulas in a most ingenious manner. He recognized that they were often caused by contusions of the soft parts which produced hematoma. He used the term "tubercle" to designate an ischiorectal abscess, the relationship between which and a subsequent fistula was quite plain to him. His treatment of a fistula was much the same as is employed today. He operated by the ligature method, namely, twisting a 5-fold strand of very slender raw linen and some horsehair, "so that it might not decay," into the fistula by means of a pewter probe, having the index finger of the left hand in the rectum at the same time to guide it. The end was then pushed out and the ligature tied down around the fistula, the knot being tightened each day until necrosis cut its way through. Furthermore, he recognized the importance of not allowing the fistulous tract to close too quickly and applied a dressing consisting of a sponge covered with honey to keep it open. His advice was against the use of the knife, preferring the ligature or "apolinose." If the latter proved ineffectual however, he used the knife, but does not give a very clear description of his technique.

Four hundred years after Hippocrates, came Celsus who added little to our knowledge of rectal surgery, although he advised the use of the knife in the treatment of fistula and the combined treatment of the knife and ligature where the fistula had many openings.

Paul of Aegina, a surgeon of the Greco-Roman school, in 600 A. D., one thousand years after Hippocrates, was the first to recommend the introduction of a sound into the fistula, pulling it in and out of the anus and cutting back down upon the tract. If the fistula had not penetrated the gut, "we must perforate it violently with the head of the sound, divide all intermediate parts, and take hold of the surrounding parts, which mostly consist of callus, with a staphylagra and cut them all out"; which sound principles of surgery as applied to fistula are well recognized today.

Paul of Aegina described complicated fistulas such as one which perforated the bladder or which extended down into the thigh; and the blind variety of fistula as being difficult, but the remainder as being easily cured.

John of Arderne was born in 1307 and probably followed the teachings of the Arabian surgeons more closely than any of his contemporaries. His works have been collected and edited by Sir D'Arcy Power and are most interesting to explore. His method of treatment of fistula was an ingenious combination of the ligature and knife and was very similar to that of Hippocrates and Paul of Aegina, although he devised some special instruments, noteworthy among which was a rectal speculum. He was quite willing to undertake complicated fistula for he cured "one that was called Thomas Broune, that had 15 holes, 8 on one side and 7 on the other, by which wynde went out with egestious odour."

Mr. W. S. Perrin considers Arderne's writings as the second landmark in the historical list of rectal surgeons, and attributes much of his success to the fact that he was one of the first to abandon the use of corrosive agents in his endeavor to cure fistula.

Following Arderne there was little progress to note until Heister, of Helmstedt published an excellent work on surgery which was translated into English in 1743. He classified fistula into complete and incomplete, simple and compound, and blind and occult. He advised the injection of a fistula with milk if it was too crooked that a probe could not follow it, and thus anticipated our modern procedure of injection with colored dyes. A whole-hearted supporter of the knife and in cutting deeply into callous fistula, he recommended that the external incision should be much larger than the internal, that there might be free access to cleanse and dress to the bottom of the sinus.

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There was little development in surgical procedure following Heister's work until the time of Allingham whose textbook appeared in 1889. In this textbook is an excellent résumé of the practice of the 19th century when rectal surgery had the advantage of anesthesia and antisepsis.

Among the Arabs some such surgeons as Avicenna, Albucasis, and Rhazes made notable contributions to the treatment of fistula. Rhazes was possibly the greatest of these surgeons. There is a legend that having already become fascinated by alchemy, Rhazes was one day carrying out certain experiments in the course of which he accidentally inhaled some poisonous fumes. He was successfully treated by a physician who submitted a bill to the amount of what would be in our money, about $1,200.00. "I perceive," Rhazes said, "that here is the true art of alchemy, or gold-making," and thereupon took up medical training.

Hemorrhoids engaged the attention of surgeons from the time of Hippocrates, second only to fistula. In reviewing ancient works one is impressed with the accurate pathological description of these lesions and the similarity of the procedures of treatment to those which exist today. Hippocrates, according to Riolly, recognized that piles could be cured "by fire," namely, by the application of hot irons to the tumefaction, and he recognized the necessity of dilatation of the anus with a convenient instrument to get to internal hemorrhoids. Astringent remedies were also a part of his armamentarium.

The needle and thread in the treatment of hemorrhoids were first used by Celsus. Allingham, in his textbook, published 13 different methods of treatment of piles ranging from excision by the knife to the Whitehead operation which has only recently been abandoned. Since the latter part of the last century, many modifications of these methods described by Allingham have been advanced, and many of his methods abandoned, but the fundamental principles remain relatively constant.

The treatment of prolapse of the rectum is described by Dupuytren as early as 1854 as follows:

> The patient is placed on his belly with the head and chest low, the pelvis well raised with pillows, and the thighs are widely separated so as to bring into view the parts to be operated on. The operator then seizes, with a pair of large dissecting forceps, the radiating folds and excises them with scissors curved on the flat. Two, three, or more of these folds or plaits are thus removed on either side in front and behind, the excision being prolonged quite to the margins of the anus, or even within it if the relaxation is considerable—the extent of the excision, in fact, bearing a relation to the laxity of the surrounding skin. The object of this operation is very simple. There is an abnormal or excessive dilatability about the anus; by the removal of the superabundant tissues, this condition is corrected and the parts within are thus shut in and prevented from becoming prolapsed, partly by curtailing the redundance in question and in part by the contraction of the neighboring tissues, resulting from inflammation and the cicatrization of the wound; the new integument being much more firm, close, and adherent to the deeper textures. In a short time the wound heals, the aperture is permanently diminished, and the cure is complete.

Dupuytren was also interested in the treatment of rectal strictures, advising four incisions of the circular band with a bistoury, and subsequent dilatation.

Thomas Copeland in his "Observations of Some of the Principal Diseases of the Rectum and Anus," written in 1810, gives a very good description of a stenosing cancer of the rectum, saying:

> The first symptom of the disease is an habitual costiveness; but this is so frequent in occurrence and produced in so many ways that it is not likely that the cause should be sought for in an organic affection of the rectum. Mild purgation is resorted to and the symptoms being relieved, the cause is no longer sought after. When this has subsisted for some time the patient complains of what is called piles, and what is often really so, as a consequence of obstructed circulation in the parts. The remedies usually given in such cases are applied, sometime with relief, but more frequently otherwise and then the good maxim of the inexpediency of curing piles, perhaps rescues the practitioner from the discredit of failing to relieve his patient. The piles are sometimes removed by ligature or excision and this gives temporary abatement of the most painful symptoms, while the cause of the disease is still unknown. In a short time as the gut continues to decrease in diameter, the efforts to expel the fæces become more violent and the consequent progress of the disease more rapid. The stools which have been evacuated with difficulty, become contracted in size, appearing like earth-worms in their form, or small pellets. In this stage it is sometimes, in the male, mistaken for enlarged prostate gland, but if the finger be introduced into the rectum, the gut will be found either obstructed with small tubercles or intersected with membraneous filaments, or else the introduction of the finger will be opposed by a hard ring of a cartilaginous feel. The patient often continues a long time in this distressing situation, until, at last worn out with pain, the discharge, or perhaps the total obstruction of the rectum, he yields to his fate.

This picture of slow, progressive stenosis parallels very closely modern observations of rectal and colonic cancers which produce obstruction before they are recognized.

Operations for cancer of the rectum date back to the proposal of Morgagni early in the 18th century and the first attempt by Faget, in 1739. The earlier procedures were all variations of a posterior type of proctectomy, leaving an uncontrollable sacral anus. The perineal method of resection usually is attributed to Lisfranc in 1826, little being known of Faget's earlier attempt in 1739. Lisfranc's first successful case was done in 1826 and reported in 1832, and meanwhile his

pupil, Pinault, published a thesis in 1829 reporting nine cases. The operation was merely a circular amputation of the anal canal. Following this however, Dieffenbach and Velpeau modified these earlier procedures. Heavy mortality followed all these procedures and surgery of the rectum languished somewhat for lack of enthusiasm among surgeons.

The modification of this operation largely revolved around whether or not to remove the coccyx, or a portion of the sacrum and the coccyx, Amussat being the first to practice coccygectomy. Verneuil, in 1873, adopted this modification routinely as giving better exposure. In 1876 Kocher took away the coccyx and a portion of the sacrum. Kraske, in 1885, made his epoch-making presentation before the Fourteenth Congress of German Surgeons. He not only removed the coccyx and a portion of the sacrum, but he suggested the preservation of the perianal skin and the external sphincter with a division of the peritoneum close to the bowel as Kocher favored. This sacral operation immediately gained popularity and maintained it for a quarter of a century. In the '90s Kraske's operation was again modified by Hochenegg, Bardenheuer, Billroth, Rehn, Rydygier, and many others who took away more of the sacrum even to the point of making osteo-integumental flaps. These procedures gained no popularity nor did the various V and H-shaped incisions of Schelky, in 1892, DePage, in 1893, or the lateral incision of Hartmann, in 1892.

It should be noted that all of these operations might be performed with or without a preliminary colostomy and that the more conservative surgeons preferred the posterior type of resection which did not open the peritoneum and left a sacral anus, while others more daringly opened the abdomen, making a colostomy and subsequent resection. There was little difference in the percentage of recurrences in the operations of this date, and the more conservative type could be performed with a lower mortality.

The history of colostomy from its inception as a decompressive measure to its present day acceptance as a necessary part of a radical maneuver for extirpation of cancer of the lower gastro-intestinal tract is an intriguing saga. Unquestionably, the medical profession was preceded by our veterinary colleagues in the performance of this operation since the latter are recorded from remote ages as having stabbed the colon of a sheep or horse suffering from obstruction, and with frequent relief.

In the ancient writing of Aurelianus it is recorded that Praxagoras, 400 years before Christ, annoyed at the unsuccessful means of treating ileus, had opened the belly and incised the bowel to evacuate its contents and then closed the bowel. There is no available record of the success of this operation.

Dinnick quotes Fine, of Geneva, who in 1797 made a contribution to colostomy in the transverse colon as observing that it was the custom to open the stomach to remove knives which had been accidentally swallowed, and praising the incision of a strangulated hernia to evacuate the bowel contents. Littre is given the credit for performing the first colostomy in 1710. As a matter of fact, Littre observing the dead body of an infant with maldevelopment of the rectum suggested an operation to overcome this by incising the abdominal wall and making either an anastomosis between the two ends of the bowel or bringing the proximal end to the surface of the belly where the anus could function. This idea, important as it was, rested for 66 years until Pillore, of Rouen, performed a cecostomy for cancer of the rectum.

After Littre and Pillore, DuBoise performed Littre's operation for an imperforate anus in 1783 but the patient, a small child, died on the tenth day. Duret, ten years later for the same lesion performed a left iliac colostomy, thus establishing the modern type of colostomy, nearly a century and one-half ago. It is true that he did this for a case of imperforate anus, but the principle was not recognized in cases of cancer of the rectum for nearly a century. Callisen, after him (1796), utilized lumbar colostomy without enthusiasm.

Amussat, an excellent French surgeon, in 1839 was actually responsible for colostomy assuming its real place in surgery. He, observing a death from obstruction due to rectal cancer, urged colostomy as a routine and humanitarian measure. A great anatomist, his contribution to the anatomy of the lumbar spaces and its relationship to the mesocolon demonstrated that lumbar colostomy, both in adult and infant subjects was possible. He performed both right and left sided decompressive operations and advanced this maneuver no little.

I am interested to note that he approved of colostomy a century ago in these words, "an artificial anus it is true is a grave infirmity, but it is not insupportable." Following Amussat we find Baudens, 1842, Keyworth, 1848, Phillips, 1850, all making technical advances in the performance of colostomy, but in 1865 Nathaniel Ward 25 years after Clements had done the first colostomy in England, urged that lumbar colostomy for rectal cancer be performed as a routine upon the recognition of the cancer.

Following Ward, Bryant and Allingham (1870 and 1874) began their contributions to rectal surgery which were landmarks in the advance to its present day status. During the last 25 years while the majority of surgeons have recognized the importance of accepting colostomy as a part of the plan for excision of rectal cancer, a great many attempts, versatile it is true, but uniformly futile, have been made to manufacture control of a colostomy by the use of the abdominal wall muscles. All of these have failed without exception. The acceptance of colostomy as a part of the operation however, has permitted the development of multiple procedures which have ranged far from the anal amputation of the 1880's to the present day combined abdominoperineal resection.

Von Volkmann, in 1887, may be said to have envisaged the so called combined abdominoperineal operation, and he published his method in a work on the removal of carcinoma of the rectum, but Czerny, in 1883, unintentionally performed an operation of this type. He was attempting to do a posterior type of excision without exploration. The growth evidently was at the rectosigmoid juncture where the majority of them are, and he was unable to bring it down so that he could resect it. Consequently, this bold and daring pioneer opened the abdomen, ligated the blood supply of the lower sigmoid, and removed the whole segment transperitoneally. Unfortunately, the attempt was unsuccessful, but a principle had been established.

At the beginning of the present century Miles began to practice this combined abdominoperineal resection of the rectum, and over the ensuing years has established it firmly as the fundamentally correct operation for cancer here. Nevertheless, it has been borne in upon the medical profession that all cancers of the rectum are not of a piece and that individualization and versatility in the matter of selection of operation is as essential here as elsewhere. Consequently, the work of Mummery, Paul, Gordon, Taylor, and many other surgeons of the British Empire, as well as Jones, David, Stone, and other American surgeons, has established the fact that the radical operation desirable as it is in one stage, may be utilized advantageously by a graded type of maneuver occasionally, and that the less radical but useful operation of colostomy and posterior resection still has definite indications.

This huge progress over the period of years in rectal surgery is a monument to these pioneers whose untiring efforts, sturdy courage, and maintenance of the highest tradition of the profession, forced progress in a field not too favorably looked upon by general surgeons as a whole because of an unwarrantably high mortality, unpleasant, and prolonged and complicated convalescence.

Surgery of the colon proper necessarily awaited its development until the era of asepsis warranted a bold invasion of the peritoneal cavity. The ancients however, recognized wounds of the gastrointestinal tract as well as invented ingenious appliances and types of sutures for their repair. In the book of Judges of the Holy Writ it is recorded that Ehud, a left handed warrior, stabbed the king of the Moabites "and his dirt ran out and he died." Similar wounds observed by Hippocrates, Celsus, and others led to the conclusion that nature was perhaps the best physician under such circumstances, and Celsus while mentioning intestinal suturing, disparaged it.

Traumatic ileostomy engaging as it did the surgeon's attention frequently, is beautifully described by William Hildani in his works done in 1644. He pictures a wound of the small bowel with prolapse of a large amount of the intestine and complete severance of the continuity of the gastro-intestinal tract, on which he made many important physiological observations.

Military surgeons observing these bizarre and deadly injuries frequently began to cast around for methods of repair and in 1730 we find Purman advocating suture with linen or catgut immersed over night in wine. Abulkasim recommended the jaws of large ants for apposing wounds and also referred to the use of catgut made from the intestines of sheep. Roger, Jamerius, and Theodoric, of Cervia, in about 1739 inserted into the bowel a hollow cylinder of elder over which the wound was sutured. Wilhelmus V. Saliceto used segments of dried animal intestine with the same object in view, and later stated that he preferred the dried trachea of a goose or some larger animal.

Samuel Sharp, in 1769 passed a needle through the lips of the wound from within outward so as to leave a length of thread at both ends to hang out of the incision, and pull the bowel so as to get adhesion. Du Verger (beginning of the 18th century) modified suturing over a cylinder by including the cylinder in the suture in a manner not practiced by earlier surgeons. Sabatini substituted for the trachea a cylinder of cardboard smeared with sweet oil, while Watson advised a cylinder of fish glue. Von Walther preferred to use a tube of India rubber.

Reybard, in 1823, after experimenting on dogs resected a portion of the sigmoid flexure in a human for cancer and performed an end-to-end anastomosis. The patient, a 29 year old man, lived one year to succumb to recurrence. Unfa-

vorable comment by his colleagues resulted in this operation lying fallow until Thiersch, in 1843, 20 years later, resected the colon again, this time for acute intestinal obstruction.

As late as 1880 only 10 resections of the large bowel were recorded, 7 of which had failed, but in the next decade the total number grew to 48 and the mortality decreased to 45 per cent. It would be difficult to attribute any particular procedure to any one surgeon prior to 1885. However, a few brief instances must be noted. Billroth, in 1879 did a resection with closure of the distal end of the bowel bringing the proximal end out as a colostomy. Schede, in the same year, brought out both ends of the bowel from the wound when he found it impossible to approximate them, and thus unintentionally performed the first graded resection of the colon. Marshall, in 1882, did Billroth's operation but made an additional stab wound incision in the left iliac region through which he made a colonic stoma. Resection of the cecum was first attempted by Kraussold, in 1879, and Maydl, in 1883, performed the first successful right colon resection in two stages, Billroth having done the one stage operation in 1884. Weir was the first American surgeon to do a successful resection of the colon. Exclusion of a segment of the bowel was first practiced by Maisonneuve while Trendelenburg and many others between 1880 and 1890 performed ileosigmoidostomy and colocolostomy.

From all this ingenuity came the gradual evolution of intestinal surgery and while many of the old surgeons observed and recorded spontaneous recovery from complete transverse wounds of the intestine by adhesion of the ends to the external wound and consequently delayed operation, they were inevitably led to attempt many methods to imitate nature. The Lambert suture is the result of the discovery that adhesion took place rapidly when serous surfaces were approximated, and a new era in intestinal surgery resulted from this single fact.

Gradually accumulated experience, buttressed by the arrival of anesthesia and asepsis forged forward through the evening of the past century to give birth to modern operative surgery. Between 1890 and 1900 many ingenious devices for intestinal suture were evolved, notably among which were Magraw's elastic ligature, in 1891, and Murphy's button in 1892. The Murphy button may be said to have revolutionized all gastrointestinal procedures.

Around 1900 a new principle in colonic surgery was firmly established as being highly desirable, largely through the efforts of Mikulicz, that is, exteriorization of the colon with its offending growth, and graded resection with subsequent reestablishment of the bowel lumen. While Bloch was the first man to do the so called exteriorization operation in 1892, its association with Mikulicz's name in this country is very common because of the latter's championing it in 1902. Bloch did an exteriorization operation in that year for acute obstruction and decompressed the colon with a tube in the proximal loop. This was a local type of operation which was subsequently modified by Hochenegg in an effort to remove the regional lymphatics, and McGraw, Allingham, and others followed a similar procedure. Paul's operation was different from that of Bloch and Hochenegg in that he excised the exteriorized portion at the time of the operation and sutured large tubes into the two limbs, the subsequent closure being made after destroying the spur after the method of Dupuytren. This exteriorization procedure reduced the high mortality which had followed colon surgery all down the years, from around 40 to 50 per cent to approximately 15 per cent.

The operation of Bloch or the exteriorization procedure was in reality the second attempt at graded resection of the colon, a principle which now is recognized as equaling in importance preoperative decompression, Schede, in 1879, having brought both ends of the bowel out of the wound when he found it important to approximate them, and thus unintentionally, as has so often been the case, established a fundamental in colonic surgery.

It is unquestionably true that the necessity of preliminary decompression of an obstructed large bowel has not been duly appreciated until the past decade. A quarter of a century ago it was recognized that slow decompression of an obstructed bladder was necessary in the treatment of prostatism. An obstructed stomach from a cicatrizing duodenal ulcer likewise was advantageously treated by preliminary decompressive measures, and obstruction elsewhere in the body was granted this preliminary emptying. With the colon it is no less desirable that the decompressive measures be noted before any radical attempt at removal be made, slow as has been the recognition of this fact.

I recall in my interne days an aphorism attributed to the late Professor L. McLane Tiffany, viz., "resection in the presence of complete obstruction is fatal," which is an accurately expressed observation. It is not too arbitrary, I think, to express the opinion that decompression preliminary to extirpation, whether it be medical or surgical, is among the most important fundamental principles in the removal of rectal and colonic cancers.

The present day concept of the surgical management of malignancies of the large bowel and rectum is the result of the gradual evolution of operative maneuvers throughout the years. The acceptance of the graded operation in many cases, and of decompression as of primary importance in all cases, has been a great step forward in establishing a satisfactory routine. It is now definitely recognized that not only should cases which are not acutely obstructed be isolated for a period of preliminary preparation and decompression, but that individualization of cases and the selection of operation for each case on its merit, rather than selection of the case for operation, is of paramount importance.

Consequently, a lowering of the hospital mortality with a widening of the operative scope has taken place to a point where surgery of the large bowel and rectum—while it may be considered a special field—has influenced standardization to the end that the principles are established and satisfactory end-results following radical surgery outbalance those of other portions of the gastrointestinal tract.

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EDITORIALS

SURGERY
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MARCH, 1937

UNDERGRADUATE TEACHING OF SURGERY

THE undergraduate teaching of surgery in our medical schools is of first importance and is being given an increasing amount of attention by surgical teachers. It must furnish all third and fourth year students with a thorough knowledge of the great variety of surgical affections, how to recognize them, and what can be done for them. But, perhaps more important, it must furnish the inspiration and stimulus which will condition the earnest study and the unswerving effort of those few individuals in the class who are destined to become leaders in surgery. To the latter end, the surgical teacher must never be unmindful.

The comprehensive groundwork is accomplished by classes, dispensary work, and clinics. The former two will usually be given by the younger men to small groups and the latter by the older men to large groups. The younger men chosen to instruct the small groups should be selected because of their alert interest in surgery. Rarely can they be accomplished surgeons themselves nor can they supply the inspiration and assuredness which comes from rich experience. These men shall teach then the printed words of the masters of surgery, and in amplifying and explaining these words they will enrich themselves.

A useful method of conducting these small classes is to divide the 45 minute period into three equal parts. During the first part the instructor may answer the most illuminating of the two written questions which each student will have handed in at the last period. These questions deal with those phases most perplexing to the student and the instructor will have ample time to have secured the proper answers. During the second part the instructor will explain the subject at hand. This explanation may be accomplished by a discussion of the studied text, by accounts or demonstrations of clinical cases, by motion pictures, by lantern slides, by charts. He will not merely recount the material the student has already studied, but he will vivify it and accentuate its practical aspects. During this period the instructor will supply the student with pertinent references. The last 15 minutes will be devoted to an informal quiz. During this part of the period the instructor will not bait and harass the student, but will merely try to bring to light the discrepancies of his teaching—wherein and how he has failed to make the subject clear.

The surgical clinics generally are best conducted by the most eminent members of the surgical faculty. There has been a growing appreciation of the limitations of the operative clinic. Often, the tiring students sit through such a period seeing almost nothing

and learning little. Better, perhaps, is the full discussion of the patient to be operated upon before the clinic. The internes or residents will clearly present the case, the surgeon will question and examine the patient, and then will explain the reasoning by which he arrives at his diagnosis. He will then outline the treatment and give careful attention to the prognosis. He will do well to imitate Lewellys Barker, Richard Cabot, or John B. Murphy. The writer has a strong feeling that while the operative clinics should not predominate, they certainly should not be excluded entirely. The conduct of the operating room, the general methods of surgery, and the administration of anesthesia are shown. Fortunate, indeed, are those students whose teacher can not only operate for them, but can vividly explain as he goes along.

The surgical out patient department is a vital part of the teaching chain. Here, the student takes his patient's history, examines him, makes a tentative diagnosis and then discusses the case with the clinical teacher. The student learns to make a careful physical examination, to interview patients, to do dressings, and to care for fractures. Here, it will be impressed upon him that all patients are to be questioned with kindness and sympathy and are to be palpated with gentleness and consideration. The patient's ailment will be discussed before him only with greatest tact. The student who acquires these qualities of sympathy, gentleness, and tact will go far.

The clinical clerkship is of greatest value. The clinical clerk is a fourth year student who is assigned for a three month period to an active surgeon. He sees at close range all the steps incident to surgical diagnosis and treatment. He makes rounds with his preceptor and is in attendance at the operating room. His work is directed by the surgical interne or resident and he participates in history taking, physical diagnosis, laboratory work, intravenous therapy, lavages, dressings, and surgical assistantships. He is generally required to prepare a number of special actual case studies which include full discussion of the current surgical literature.

The surgical ward walks are another important phase of surgical teaching. Here, important phases of diagnosis and after-treatment are impressed upon the student.

It is of outstanding importance to a surgical teacher that he always have in mind those unknowns among his students who are to be the surgical leaders of tomorrow. In them he must implant an unquenchable fire of interest, the will to learn the truth, the duty to add to the sum of surgical knowledge, and the realization of the great power to alleviate suffering which lies in the hands of the true surgeon. He must strive to make his personal example admired and respected, and he must give serious attention to his student's questions.

With such a groundwork as just described, the student will be prepared for his internship and his residencies.

FREDERICK CHRISTOPHER.

PSEUDOBILIARY DYSKINESIA

THE recent, widespread interest in biliary dyskinesia, coupled with the work elaborated in the experimental laboratory on drugs useful for the release of spasm of the sphincter of Oddi, has raised a new problem in the diagnosis of biliary diseases.

Biliary dyskinesia was first elaborated as a clinical diagnosis by Westphal following the earlier anatomical work of Doyen and Oddi. His conception of biliary dyskinesia was that it represented a purely functional spasm of the sphincter of Oddi. By increasing use, the term has been extended to include all spasms of the

sphincter regardless of functional, mechanical, or irritative origin. The confusion which may arise from the indiscriminate use of the term biliary dyskinesia has been commented upon by various observers. Experience has shown that the more common misuse of the term is in postcholecystectomy pain in which the symptoms are due to overlooked stones in the common duct and in which relief of symptoms is being attempted by drugs designed to relieve spasm of the sphincter of Oddi. In jaundice due to early carcinoma of the pancreas, false hopes may be aroused by a diagnosis of functional spasm of the sphincter. In certain infections of the biliary tract and of the liver, a diagnosis of functional spasm may be easier to justify, but in 2 such cases one subsequently proved to be cholangitis and the other subacute necrosis of the liver. That the true condition of affairs may be overlooked by assuming that the symptoms are due to functional spasm alone, is shown by the fact that in only one of a series of cases in which a diagnosis of biliary dyskinesia had been made was the condition shown to be a purely functional disorder, and in this instance the symptoms were readily relieved by amyl nitrite.

These experiences lead me to plead for a return to the original concept of biliary dyskinesia, namely a functional spasm of the sphincter of Oddi. When spasms occur in association with stones or infection in the common duct, the lesion should be diagnosed as choledocholithiasis or cholangitis, respectively, with spasm. The importance of this differentiation is obvious, for the treatment may be entirely different in each of the three lesions. If biliary dyskinesia is to be maintained as a clinical entity, as it should be by virtue of its physiologicopathological mechanism and release by clinical methods, it must not be confused with other lesions in the common duct which demand entirely different therapeutic measures.

STANLEY H. MENTZER.

MASTER SURGEONS OF AMERICA

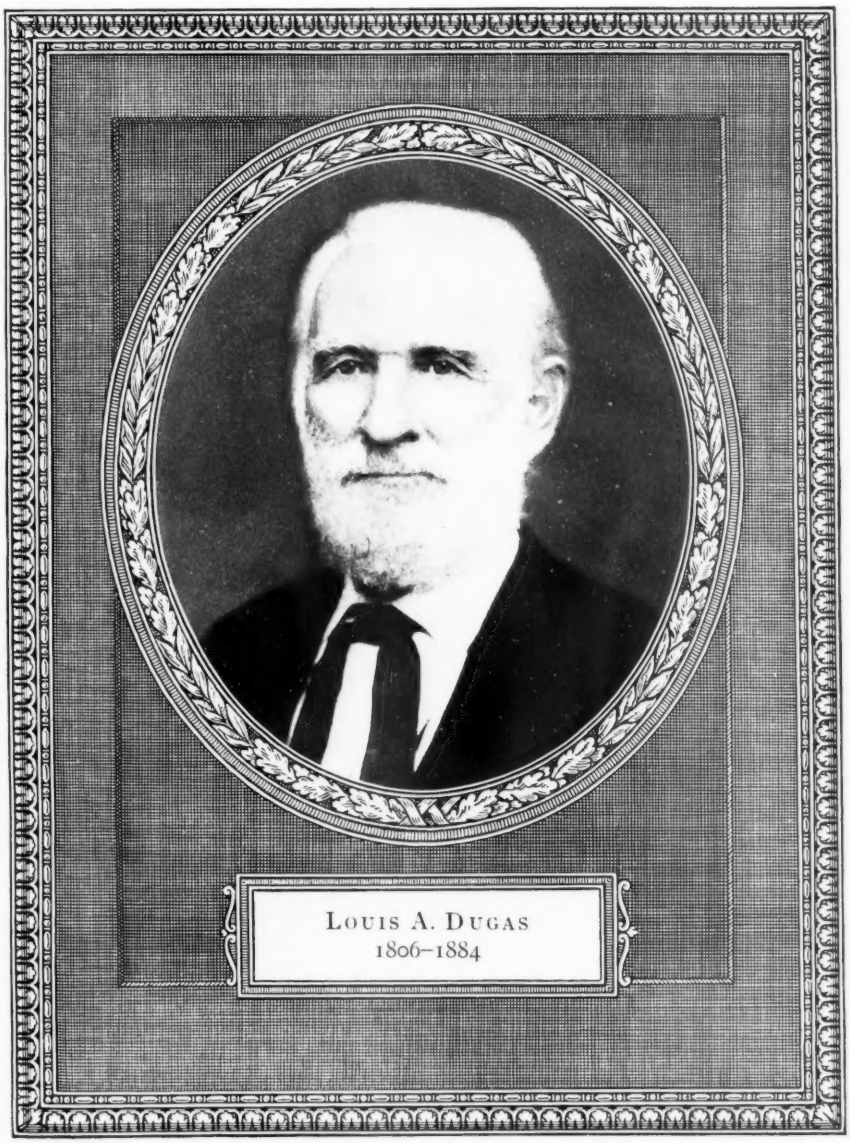
LOUIS ALEXANDER DUGAS

"IT is by observation and the accumulation of facts alone, that any permanent improvements have been made in our profession." Thus did Dr. Dugas address the graduating class of the Medical College of Georgia on March 6, 1841. From a perusal of his writings it must be concluded that he was a keen observer; subsequent developments have proved that he enunciated certain facts that have aided no little in the advancement of the art and science of medicine.

Louis Alexander Dugas was born on January 3, 1806, in Washington, Georgia, and was the son of Louis Rene Dugas de Vallon. The de Vallons were of French West Indian descent, emigrating from France to St. Domingo, where they became opulent planters. M. de Vallon, though born in St. Domingo, resided in Paris. His mother before her marriage to M. de Vallon was Mary Pauline Bellumeau de Vincendire, also a native of St. Domingo, where for generations her ancestors had been wealthy planters. The de Vincendires educated their children in Paris, and it was there that M. de Vallon met Mademoiselle de Vincendire. They were married in August, 1790. Soon thereafter, on account of the Revolution, they left France for St. Domingo; but because of the political turmoil there the Dugas family sought refuge in the United States. In 1791 they landed in Charleston, and, deferring to the republican simplicity of their adopted country, dropped the de Vallon from their name, and were henceforth known as Dugas.

From Charleston the family resided successively in Georgetown, South Carolina; Newport, Rhode Island; Fredericktown, Maryland; and Savannah and Washington, Georgia. It was at the latter place that Louis Alexander, with a twin brother, Louis Charles, was born. The means of the family were practically exhausted, and Louis Alexander's mother, an accomplished and cultivated woman, opened a female seminary. After the death of her husband she decided to move to Augusta, Georgia, where a similar institution was established. Here she was so successful that she was able to educate her children and lay by a competency. Young Dugas was instructed by his mother until the age of 14, with the exception of two or three quarters passed at the Academy of Richmond County.

About this time Dr. Charles Lambert de Beauregard, a French emigré, came to Augusta. He became intimate with the Dugas family and proffered his services to give Louis Alexander a medical education. Dugas entered the doctor's office in 1820, and remained until his preceptor died in 1822. During these two years he was too young to devote himself entirely to the study of medicine, so used his spare moments to enrich his mind with an extensive course of general reading. The year after Dr. de Beauregard's death he entered the office of Dr.



LOUIS A. DUGAS
1806–1884

John Dent, where he continued the study of medicine for two years. He then went to the University of Maryland for the winter term; thence to The Philadelphia Medical Institute for the summer course. The following winter he returned to Baltimore, and was graduated from the University of Maryland in 1827.

The year following his graduation he spent on the plantation of a friend in Georgia. Here he pursued his studies in quiet, and meditated without fear of interruption. Early in 1828 he sailed for Europe, where he remained for over two years. He visited England, France, Germany, Switzerland, and Italy, but made Paris headquarters. In Paris he enriched his knowledge of medicine but did not neglect to round out his education in the academic field. His mornings were occupied with hospital rounds, lectures, and postmortem studies, but the afternoons were spent at the Sorbonne. In this arduous 16 hour day he came under the influence of such illustrious teachers as Gay-Lussac, Cuvier, Magendie, Roux, Velpeau, Dupuytren, Lisfranc, Guizot, Baron Larrey, Dubois, and Louis.

In July, 1831, he returned to Augusta where he began the practice of his profession. Soon thereafter he was approached by Dr. Milton Antony concerning the establishment of a Medical Academy in Augusta. Dr. Dugas offered to co-operate provided the name was altered to that of a Medical College; and in 1832 The Medical College of Georgia was founded with Dr. Milton Antony, Dr. Lewis D. Ford, Dr. Joseph A. Eve, Dr. Paul F. Eve, Dr. John Dent, and Dr. L. A. Dugas in the various chairs, the latter first teaching anatomy and physiology. In 1855 he was made professor of the principles and practice of surgery, which position he filled until 1882, when he retired from active work. For 20 years he was dean of the college. Endowed with unusual mental equipment, and the advantages of education and travel, in 1835 we find him and his colleagues vainly suggesting higher standards for medical education.

In 1834 Dr. Dugas again visited Europe. This time the faculty of the school gave him $6,000.00 with which to purchase a museum, books for the library, and chemical apparatus for the college. The minutes of the faculty disclose how well pleased his colleagues were with his mission, that his vouchers were certified as being correct and business-like; and that he returned quite a sum to the college treasurer. During this second visit to Paris he was elected a member of the Geologic Society of France. Upon his return to Augusta he resumed his professional work, paying particular attention to surgery. In 1851 he visited Europe for the third time; and in the same year became editor of the *Southern Medical and Surgical Journal*, which position he held for seven years.

Dr. Dugas never doubted the right of the southern States to secede, but was utterly opposed to secession as unwise and necessarily destructive, whether successful or not, to the best interests of the country. Having strong objections to military control he volunteered as surgeon with General Walker, and served with his brigade as long as they remained on the coast. Later he was appointed con-

sulting surgeon to the military hospitals in Augusta. In the latter assignment he saw many cases of hospital gangrene, and finding the usual remedies, and dilute Labarraque's solution was his favorite, of no avail, he recommended the use of tar water: made by "pouring a gallon of hot water upon a gill of pine tar and stirring it a little. It is the best disinfectant I know of in hospital gangrene, and altogether, I think, the best application."

Dr. Dugas wrote eighty-nine articles for the *Southern Medical and Surgical Journal*. He also contributed to the *New Orleans Medical and Surgical Journal*, the *Atlanta Medical and Surgical Journal*, the *Transactions of the American Medical Association*, and the *Transactions of the International Surgical Congress*. They ran the gamut of what was then medical knowledge. He reported a successful excision of a stricture of the pendulous urethra in 1837. He was a strong believer in the value of mesmerism, and on January 12, 1845, had another induce the mesmeric state in a female patient with what must have been a carcinoma of the breast, excised the breast in the presence of some of his colleagues, with the patient afterward stating that she felt no pain. The tumor recurred, and it was again removed under mesmerism; and finally she had a recurrence *in situ* with axillary metastases. Mesmerism was again resorted to, and both the recurrence and axillary metastases were removed without pain. Doubtless the discovery of the anesthetic properties of ether estopped his investigations along this line.

Dr. Dugas is best known for "Dugas's sign" for dislocations of the shoulder-joint. His "Remarks on the Diagnosis of Dislocations of the Shoulder Joint" was published in 1856. In this he stated: "A concurrence of circumstances can alone be relied upon in certain cases to make the diagnosis of dislocation clear and positive. If the fingers of the injured limb can be placed (by the patient or surgeon) upon the sound shoulder while the elbow touches the thorax, there can be no dislocation, and if this *cannot* be done, there *must* be a dislocation."

His article, "Remarks upon Penetrating Wounds of the Abdomen with the Suggestion of a Change of Practice in Such Cases," read before the surgical section of the International Medical Congress in Philadelphia in 1876, is his outstanding contribution to surgical thought and teaching. It stamps him as an original and bold thinker, and history has proved the wisdom of his suggestions. He prefaced his recommendations by saying:

> "The peritoneum is not an organ of such vital importance as to render its inflammation necessarily fatal. If the intestines protrude and are found to be wounded, we are advised to cleanse, stitch, and return them to the cavity; otherwise the case is to be trusted to nature. The recent occurrence of several fatal cases in our neighborhood prompts me now to a more formal appeal to the profession for a reconsideration of the principles by which we have been governed in such cases, and to suggest that in all instances of penetrating wounds of the abdomen, in which there may be any suspicion of the existence of effusion of blood or feces into the peritoneal cavity, the surgeon should proceed immediately as follows: (1) Induce anæsthesia; (2) Lay open the abdomen along the linea alba, freely enough to make

a thorough inspection of the parts contained; (3) Ligate all bleeding vessels as far as possible; (4) Examine carefully the whole length of the alimentary canal, in order to detect any wounds, and to stitch them. If the intestinal wound be ragged it should be trimmed down to a straight edge; (5) In gunshot wounds reduce the channels of entrance as well as of exit through the abdominal walls to the form of incised wounds, so that these may be closed and left to adhere by first intention; (6) Cleanse the wounds and peritoneum of all extraneous materials, and close the abdominal walls with suitable sutures and adhesive plasters; (7) Finally, control the peristaltic action with opium, and administer such nourishment as will leave the least fecal residuum."

He preferred ether to chloroform on account of its safety. For suturing intestines he used "animal ligatures of catgut or violin strings wet with antiseptic solutions." As early as 1853 we find Dr. Dugas having microscopic diagnoses of tissues removed at operation; and he never let go by an opportunity to get an autopsy. When one considers the times, the smallness of the community in which he labored, and the conservativeness of the population, the number of postmortem examinations he was able to obtain was quite remarkable.

In addition to his profession Dr. Dugas was an admirable and useful citizen. He was a member of the board of trustees of Richmond Academy for 39 years; and served as the president of this body for 25 years. This educational institution is one of the oldest on the Continent, having been established and endowed by George III. He was repeatedly elected to the city council and while a member of that body was instrumental in having a monument erected to three Revolutionary patriots—the three men from Georgia who signed The Declaration of Independence: Lyman Hall, George Walton, and Button Gwinnett.

Dr. Dugas many times was elected the president of the local Medical Society; was three times president of the Medical Association of Georgia; and was one of the vice presidents of the International Medical Congress. In 1869 The University of Georgia conferred on him the degree of Doctor of Laws.

In 1833 he married Miss Mary C. Barnes of Columbia County, Georgia. To them was born one daughter who married Dr. William I. Holt of Montgomery, Alabama. His first wife lived only a little over one year. In 1840 he married Miss Louise V. Harriss, also of Columbia County. From this union there were three sons and two daughters. One son, Dr. George Cuvier Dugas, succeeded his father as professor in the Medical College.

Dr. Dugas died October 19, 1884, and was mourned not only by his family and colleagues but by the whole community. In an editorial in the *Augusta Chronicle*, The Hon. Patrick Walsh, then its editor, said: "He had great talents and used them for the highest purposes. His modesty was co-equal with his mental endowment, and the ambition to dazzle the world sensationally was foreign to his nature."

GEORGE A. TRAYLOR.

Estate of Capt: John Vicary deceased - - - - - to Dr Physick.

For Attendance and Medecines administered to
his daughter Miss Rebecca Vicary bet.n 29th Sept.r
1794 & 27th Jan.y 1795 - - - - - - - - - - - £5-5-0

Dr Phisycks Account
for attending Rebecca Vicary
Pd & entered 22nd October 1795

V

Facsimile of a bill submitted to Estate of Capt. John Vicary by Dr. Philip Syng Physick for attendance upon Miss Rebecca Vicary from September 29, 1794, to January 27, 1795.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE seventh edition of the well known textbook, *Williams' Obstetrics*,[1] has been revised and certain sections rewritten by Stander. The book has been accepted as a classic for so long that an extended review is hardly necessary. The general plan of the book is the same with a slight rearrangement of some of the chapters and the addition of three new chapters. There has, of course, been a revision where necessary to bring the text up to date. Several new excellent illustrations have been added as well as several new photographs. The book is intended for students and practitioners and is "predominantly conservative." As in previous editions a bibliography appears at the end of each chapter which is a distinct aid to anyone who wishes to refer to the original sources.

The chapter on "The Sex Hormones—Their Relation to Menstruation, Pregnancy, Parturition, and Lactation" presents the endocrine problem clearly and concisely. This field of medicine has been making rapid strides in the past few years, and Dr. Stander presents the latest views on this subject as well as the historical background for our present knowledge. Diseases of the kidneys and urinary tract is a new chapter in which the urological complications of pregnancy are discussed quite fully and "are given the emphasis they deserve." The different forms of nephritis and their significance in the gravid state have been correlated with the toxemias of pregnancy as in previous editions. A new chapter on amnesia, analgesia, and anesthesia in labor discusses the problem from earliest times to the present with a thoroughly conservative attitude and gives in detail the methods which are at present employed at the New York Lying-In Hospital.

This text should meet with the approval of teachers of obstetrics and practitioners and is an excellent text for students. T. J. MORRIS.

THE necessity of revising *The Anaemias*[2] in the short space of 2 years is a "measure of the activity among hematologists." The subject matter is taken up in chapters under the general headings of normal erythropoiesis, erythropoietic activity, classification of anemia, hypochromic anemia, macrocytic anemia, anemia from deficiency of vitamin C and thyroxin and consecutively toxic, unexplained, posthemorrhagic, hemolytic and unclassified anemias. Each individual type of anemia is discussed from the standpoint of etiology, symptomatology, diagnosis, and treatment. Descriptions of the normal anatomy of erythropoiesis and the pathological physiology of the various anemias have been contributed by Professor H. M. Turnbull. A number of valuable illustrations help to clarify various descriptions given in the text. Included are several red cell diameter distribution curves (Price-Jones) typifying some of the common anemias as well as interesting roentgenograms from cases of anemia in which bone lesions occur.

In the preface, Dr. Vaughn states: "If no spectacular additions to knowledge have been made in the last two years, at least much of the previous rapid advance has been well consolidated." The book has been lengthened from 248 to 309 pages and the bibliography increased from around 350 to over 500 references. A special chapter has been devoted to erythropoietic activity which was formerly more briefly considered. Among the factors essential to normal erythropoiesis, the author has added bile pigment and chlorophyll and (with a question) secretion from the posterior lobe of the pituitary gland. A discussion of the significance of the reticulocyte response has also been included in this chapter. Under the heading of anemia due to lack of the pernicious anemia factor has been added a section on "Megalocytic Hyperchromic Anemia Associated with Liver Disease." The term "hyperchromic" is used to denote a high color index and not an increase in the hemoglobin concentration. Four excellent colored plates of blood films from various anemias have been included in this volume. There is also a fine illustration of spoon shaped finger nails (koilonychia) from a case of idiopathic hypochromic anemia. This volume is improved and brought up to date and it should therefore retain its place among the standard reference books on anemia.

HOWARD L. ALT.

IN a small book of 117 pages entitled *Squint Training*,[3] M. A. Pugh, medical officer in charge of the orthoptic department of the Royal London Hospital, presents the technique of orthoptic training as it is practiced by the author, and discusses directly related subjects.

A brief classification of the types of squint and the methods used in the preliminary investigation of a squint case are given. This is then followed by the most important part of the book, the discussion on binocular vision in strabismus, its analysis into two groups: (A) those of normal retinal correspondence;

[1] WILLIAMS' OBSTETRICS, A TEXTBOOK FOR THE USE OF PRACTITIONERS. By Henricus J. Stander, M.D., F.A.C.S. 7th ed. (A revision and enlargement of the text originally written by J. Whitridge Williams.) New York and London: D. Appleton-Century Co., 1936.

[2] OXFORD MEDICAL PUBLICATIONS. THE ANAEMIAS. By Janet M. Vaughn, D.M. (Oxon.), M.R.C.P. (Lond.). With Notes on the Normal and Pathological Erythropoiesis by Hubert M. Turnbull, D.M. (Oxon.), F.R.C.P. (Lond.). 2d ed. London: Oxford University Press, 1936.

[3] OXFORD MEDICAL PUBLICATIONS. SQUINT TRAINING. By M. A Pugh, M.R.C.S. (Eng.), L.R.C.P. (Lond.). London: Oxford University Press, 1936.

and (B) those of abnormal retinal correspondence. Having separated the two groups the author then discusses the training of each group in detail. This involves the topics of amblyopia, suppression, the development of fusion and fusion amplitude, the development of stereoscopic vision and in group B. the development of normal retinal and macular correspondence. A chapter is presented on the selection of cases for surgery with an analysis of a series of cases treated by different surgical methods without orthoptic training and the results obtained. The next chapter presents the results obtained by the treatments of refraction, occlusion, orthoptic training, and operation as an aid to orthoptic training. The last chapter is on orthoptic instruments and their development.

There are a few facts to be noted about the book. The subject matter presented is entirely that of the experience of the author. There are no direct references given. There is an excellent summary comparing the results of the various treatments of squint and the value of orthoptic training. This is clearly shown by some of the author's tables. The instrument upon which such a comprehensive study and the method of training was based, is the orthoptoscope, a giant amblyoscope. Without such an instrument a duplication of the author's procedure would be difficult. The book is to be recommended for those interested in the treatment of squint.

WILLIAM H. DROEGEMUELLER.

THE voluminous data presented by Schuberth[1] regarding the disturbance of circulation in spinal anesthesia, as obtained from experiments on rabbits and man, indicate that the fall of blood pressure in spinal anesthesia is not due to paresis of the intercostal nerves, and that in most cases of spinal anesthesia there is an increase in the arteriovenous difference, and a decrease in cardiac output. The peripheral circulatory insufficiency and hypotension of spinal anesthesia are used to define the term "shock."

JOHN MARTIN.

[1]ACTA CHIRURGICA SCANDINAVICA. Vol. 78, Supplement 43—ON THE DISTURBANCE OF THE CIRCULATION IN SPINAL ANAESTHESIA; AN EXPERIMENTAL STUDY. By Oscar O. Schuberth. Stockholm: P. A. Norstedt & Sons, 1936.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

SYNOPSIS OF ANO-RECTAL DISEASES. By Louis J. Hirschman, M.D., F.A.C.S. St. Louis: The C. V. Mosby Co., 1937.

TRANSACTIONS OF THE FIFTY-SEVENTH MEETING OF THE AMERICAN SURGICAL ASSOCIATION. Held at the Northwestern University, Chicago, Ill., May 7, 8, 9, 1936. Vol. 54. Edited by Walter Estell Lee, M.D. Philadelphia: J. B. Lippincott Co., 1936.

UEBER DIE GEBURTSTRAUMATISCHEN SCHAEDIGUNGEN DES ZENTRALNERVENSYSTEMS. By Dr. med. habil. H. Nevinny. Stuttgart: Ferdinand Enke, 1936.

THE MANAGEMENT OF OBSTETRIC DIFFICULTIES. By Paul Titus, M.D. St. Louis: The C. V. Mosby Co., 1937.

ANNUAL REPORT OF THE SURGEON GENERAL OF THE PUBLIC HEALTH SERVICE OF THE UNITED STATES FOR THE FISCAL YEAR 1936. Washington: U. S. Government Printing Office, 1936.

PHYSICAL THERAPEUTIC METHODS IN OTOLARYNGOLOGY. By Abraham R. Hollender, M.D., F.A.C.S. St. Louis: The C. V. Mosby Co., 1937.

KIDNEY PAIN; ITS CAUSATION AND TREATMENT. By J. Leon Jona, D.Sc.(Adel.), M.D.(Melb.), M.S.(Adel.), F.R.A.C.S., M.C.O.G. London: J. & A. Churchill Ltd., 1937.

TRATADO DE OBSTETRICIA. By Manuel Luis Pérez. Vol. 1—EL EMBARAZO; EL PARTO; EL PARTO SEGUN LAS DISTINTAS PRESENTACIONES; EL ALUMBRAMIENTO; EL EMBARAZO MULTIPLE; EL RECIEN NACIDO; EL RECIEN NACIDO DEBIL CONGENITO. Vol. 2—EL EMBARAZO Y EL PARTO PATOLOGICOS; LAS OPERACIONES; EL ALUMBRAMIENTO Y EL PUERPERIO PATOLOGICOS; EL RECIEN NACIDO PATOLOGICO. 2d ed. Buenos Aires: Aniceto López, 1936.

THE LUNG. By William Snow Miller. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1937.

CARCINOMA OF THE FEMALE GENITAL ORGANS. By M. C. Malinowsky and E. Quater. Translated from the Russian by A. S. Schwartzmann, A.B., M.D. Boston: Bruce Humphries, Inc., 1936.

OXFORD MEDICAL PUBLICATIONS. DISEASES OF THE NEWBORN. By Abraham Tow, M.D. New York: Oxford University Press, 1937.

HEART DISEASE. By Paul Dudley White, M.D. 2d ed. New York: The Macmillan Co., 1937.

THE COLON AS A HEALTH REGULATOR—FROM A SURGEON'S POINT OF VIEW; THE EFFECTS AND TREATMENT OF ITS DEVELOPMENTAL ABNORMALITIES. By Sir Henry M. W. Gray, K.B.E., C.B., C.M.G., LL.D.(Aberdeen), M.B., C.M.(Aberdeen), F.R.C.S.(Edinburgh). Toronto: The Macmillan Co. of Canada Ltd., 1936.

AN INTRODUCTION TO PHARMACOLOGY AND THERAPEUTICS. By J. A. Gunn, M.A., M.D., D.Sc., F.R.C.P. 5th ed. New York and London: Oxford University Press, 1936.

SCALPEL AND SWORD. By Sir James Elliott. Wellington, New Zealand: A. H. and A. W. Reed, 1936.

INHALATION ANESTHESIA; A FUNDAMENTAL GUIDE. By Arthur E. Guedel, M.D. New York: The Macmillan Co., 1937.

MEDICAL MORALS AND MANNERS. By Hubert Ashley Royster, M.D. Chapel Hill, N. C.: The University of North Carolina Press, 1937.

PÉRIODE DE FÉCONDITÉ ET PÉRIODES DE STÉRILITÉ CHEZ LA FEMME. By H. Vignes and M. Robey. Paris: Masson et Cie, 1936.

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HAUTDESINFEKTIONSPROBLEME. By Jorgen Ernst. Kopenhagen: Levin & Munksgaard, Ejnar Munksgaard, 1937.

THE FUNDAMENTALS OF ELECTROCARDIOGRAPHIC INTERPRETATION. By J. Bailey Carter, M.D. With a foreword by Horatio Burt Williams, M.D. Springfield, Ill. and Baltimore, Md.: Charles C. Thomas, 1937.

Painting by E. Hamman

Original Lithograph by A. Mouilleron

Andreas Vesalius

1514-1564